Alkyl Lead Inventory Study

SOURCES, USES AND RELEASES IN ONTARIO, CANADA

A PRELIMINARY REVIEW

Prepared for:

Environmental Contaminants &
Nuclear Programs Division
Environmental Protection Branch -
Ontario Region
Environment Canada

Prepared By:

Jack Patriarche MBA, P.Eng.
Ian D. Campbell BSc, PhD
Patriarche & Associates

January 1999

DISCLAIMER:

The information contained in this report has been prepared by Patriarche & Associates. It represents the opinions of the authors, and should not be construed as representing the policy of Environment Canada.

PATRIARCHE & ASSOCIATES
15105 Yonge Street, Suite 202
Aurora, ON L4G 1M3
Tel: 905-726-1011, or 416-937-7652
Fax: 905-726-1243
e-mail: info@patria.on.ca

EXECUTIVE SUMMARY

The Binational Toxics Strategy (BNS) is a cooperative enterprise between Environment Canada and the US Environmental Protection Agency. Under this strategy, Canada and the US have agreed to work toward the virtual elimination of a variety of toxic substances. One of these substances is alkyl lead.

The BNS establishes 1988 as the base year for alkyl lead, and challenges Canada to:

Seek by 2000, a 90% reduction in use, generation, or release of alkyl lead consistent with the 1994 COA.[1]

This report evaluates Canada's progress in meeting that challenge, and looks at the sources, uses, and emissions of alkyl lead.

Sources

There are no domestic sources of alkyl lead in Canada. Alkyl lead is imported from the US, and is used in two refineries (Edmonton and Montreal) to blend leaded aviation gasoline (avgas). Virtually no avgas is produced in Ontario at this time.

Uses

Alkyl lead — specifically tetraethyl lead (TEL) — is added to gasoline to raise the octane level. Higher octane gasoline allows for higher compression ratio engines, which results in greater thermodynamic efficiency. This increase in thermodynamic efficiency enables engine manufacturers to get more power and fuel efficiency from smaller and lighter engines.

In the mid-1970s, catalytic converters were introduced to reduce tailpipe emissions from automobiles. To function properly catalytic converters require unleaded gasoline. The lead in leaded gasoline adheres to the surface of the catalytic converter, preventing it from removing harmful tailpipe emissions. With a few exemptions, leaded gasoline was banned in Canada by 1990 and by this time almost all motor vehicles were equipped with catalytic converters and running on unleaded gasoline. Since 1990, the remaining uses of leaded gasoline have been fuel for light aircraft and competition vehicles.

The Canadian Challenge of reducing alkyl lead use by 90% between 1988 and 2000 has been exceeded. By 1997, leaded gasoline sales in Ontario had declined from about 3 billion litres in 1988 to roughly 33 million litres — a reduction of almost 99%. Of the

---

[1] COA — Canada – Ontario Agreement. Signed in 1994, this agreement between the Governments of Canada and Ontario provides for a framework for systematic and strategic coordination of shared federal and provincial responsibilities for ecosystem management in the Great Lakes Basin. Tier I and II substances, and their targets for reduction, have been incorporated into the BNS.

remaining permitted uses of alkyl lead, the most significant is aviation gasoline. The 33 million litres of leaded gasoline consisted of 6.6 million litres (20%) of leaded motor gasoline and 26.7 million litres (80%) of aviation gasoline. However, aviation gasoline (avgas) represented only 1.5% of total aviation fuel use in Ontario (almost 1.8 billion litres for both jet fuel and avgas). Jet fuel does not contain alkyl lead. Relative to total motor gasoline sales (mogas), avgas and leaded mogas comprised only 0.2% and 0.05%, respectively, of Ontario's gasoline mix in 1997.

There is limited scope for replacement of leaded avgas in commercial aircraft because the octane requirement is not easily met by any means other than tetraethyl lead (TEL). Without the octane supplied by TEL, aircraft engines under full load are subject to auto-ignition, which causes power loss and potentially engine failure. An aircraft taking off with a full load of passengers or freight would stand a substantial risk of crashing if this were to occur.

Emissions and Releases

Emissions generally may occur in two ways — tailpipe emissions from the combustion process in the engine or evaporative emissions from storage tanks (standing losses) and during refilling. Tailpipe emissions of alkyl lead are essentially zero as virtually all alkyl lead is consumed in the combustion process. Evaporative emissions of alkyl lead are in the order of 7.4 kg per year in Ontario, with an atmospheric half-life of less than 12 hours. Evaporative emissions of alkyl lead are not considered an environmental problem, and were therefore not examined in any further detail.

Releases are generally in the form of spills and/or leaks. Spills involving avgas, reported to the Ontario Spills Action Centre, are minimal. Only one reported spill out of roughly 200 substance spills at airports between January 1993 and October 1998 was identified as avgas.

Leaks from old underground storage tanks at airports may be a problem. There is no central database that identifies number, age, and condition. Just over 100 of Ontario's 300 land aerodromes have fuel storage facilities. Jurisdiction over these facilities is shared among federal and provincial governments, and among transportation, environment, and natural resources ministries. Environment Canada estimates that 5% of petroleum product storage systems on federal lands are leaking. Following Environment Canada's conclusions, it may be suggested that storage systems at airports on non-federal lands exhibit leaks at a similar rate.

It is recommended that an inventory of fuel storage facilities at Ontario airports be undertaken. This inventory should mirror the registration requirements published in the *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations* in January of 1997 under CEPA.

Based on 1997 measurements of lead content in the soil and air near racetracks, it has been concluded that lead emissions are essentially a non-issue. It would be useful to conduct similar sampling near small airports when there are aircraft (fuelled by leaded avgas) in the circuit to determine the level of exposure to inorganic lead and confirm that it is as low as it is at the racetracks where the measurement program took place.

It is recommended that there be no effort to mandate elimination of leaded avgas at this time until a feasible alternative has been found.

CONTENTS

APPENDICES

A CONTACTS

B REFERENCES

C ONTARIO AIRPORTS

D AVIATION FUEL IN CANADA

E ALKYL LEAD

F REGULATORY FRAMEWORK

G GLOSSARY

1.0 INTRODUCTION AND PURPOSE

The purpose of this report is to review the sources, uses, and potential releases of alkyl lead in the Province of Ontario. The impetus for this report is the Binational Toxics Strategy (BNS), an agreement between Environment Canada and the US Environmental Protection Agency to work towards the virtual elimination of persistent toxic substances in the Great Lakes Water Basin. Alkyl lead is a Level 1 (high priority) substance under the BNS.[2]

Alkyl lead compounds are organometallic compounds in which an atom of lead is covalently bonded to three or four carbon atoms. The three most common alkyl leads are tetraethyl lead (TEL), tetramethyl lead (TML), and triethyl lead.

Currently, the only use for alkyl lead compounds is as an additive in gasoline for spark-ignited internal combustion engines. Alkyl lead boosts octane, and provides lubrication and protection against recession of intake and exhaust valves.

Octane is a measure of gasoline's resistance to auto-ignition[3] during the compression cycle of a spark-ignited engine. Alkyl leads decompose in the compression cycle, forming lead oxide particles. These particles react with hydrocarbon radicals, interrupting the chain-branching reactions that would otherwise lead to irregular combustion. This prevents spontaneous auto-ignition, instead producing a uniform, controlled burn with maximum power.

TEL is the alkyl lead used in Ontario gasolines. An excess of ethylene dibromide (EDB) and ethylene dichloride (EDC) is also added to act as scavengers[4], in the molar ratio 1:2. During combustion, EDB and EDC decompose to form hydrogen bromide and hydrogen chloride, respectively. The hydrogen bromide and hydrogen chloride react with the lead oxides to form volatile lead halides, effectively removing all the lead from the combustion chamber. Only a very little alkyl lead (approximately 0.3%) survives the combustion process.[5] The remaining lead compounds that can be present in the exhaust gases include a wide range of lead oxides, halides, sulphates, phosphates, oxyhalides, and oxysulphates. The focus of this project was limited to alkyl lead (organolead) compounds.

---

2 *The Great Lakes Binational Toxics Strategy*. Canada – United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes.

3 Sometimes called pre-ignition, knock, or ping, this is the spontaneous ignition in different parts of the combustion chamber of the air-fuel mixture prior to the timed spark ignition. The collision of these flame fronts results in "engine knock" or detonation. See Appendix G – Glossary.

4 "Scavengers" act to prevent the build up of lead deposits in an engine's combustion chamber by making the lead compounds sufficiently volatile that they will pass through the exhaust system.

5 Grandjean, P. "Health Significance of Organolead Compounds". *Lead Versus Health*, edited by M. Rutter and R. Russell Jones. John Wiley & Sons Ltd. 1983.

The Binational Toxics Strategy (BNS) establishes 1988 as the base year for alkyl lead, and challenges Canada to:

> *Seek by 2000, a 90% reduction in use, generation, or release of alkyl lead consistent with the 1994 COA.*[6]

This report evaluates Canada's progress in meeting that challenge.

---

[6] COA — Canada – Ontario Agreement. Signed in 1994, this agreement between the Governments of Canada and Ontario provides for a framework for systematic and strategic coordination of shared federal and provincial responsibilities for ecosystem management in the Great Lakes Basin. Tier I and II substances, and their targets for reduction, have been incorporated into the BNS.

2.0 METHODOLOGY FOLLOWED

The methodology used primary (interviews) and secondary (existing documentation) research, with the emphasis on secondary research. The geographic focus for the report was Ontario, although data limitations required some sections to be general to Canada. For example, data on imports of tetraethyl lead and on the competition vehicle sector could be completed only at the national level. Some of the discussion of commercial aviation versus recreational flying were was also feasible only on a national basis.

A review of published reports, analyses, statistical data, and discussion with a broad spectrum of individuals knowledgeable in their respective fields (Appendix A lists contacts and Appendix B lists references) suggests a decline in use of alkyl lead.

3.0 SOURCES OF ALKYL LEAD

There are very few producers of alkyl lead in the world. The principal ones are The Associated Octel Company, England, and Ethyl Corporation, USA, with minor suppliers in Germany and Russia.[7]

The market for leaded Anti Knock Compound (AKC), which is primarily composed of alkyl lead, is in terminal decline according to Mr. Bob Larbey, Manager, External Affairs for Octel. He estimates that the global market is only 10% of what it was in 1973, and continues to decline by 10-15% per year. At this rate, it is likely AKC will be used almost exclusively for small piston-engined planes.

In the 1980s, there were two producers of alkyl lead in Ontario — DuPont in Maitland, and Ethyl in Corunna. DuPont closed its operation in 1985 and Ethyl Canada followed in 1994.[8] Since 1994, there has been no domestic production of alkyl lead in Ontario. In 1995, Putnam (1995) reported that Ethyl maintained a small inventory of "motor mix" at its Corunna plant.[9] Recent discussions with representatives of Ethyl Corporation indicate that this inventory has been dispersed.[10] Current demand for AKC is supplied primarily through Ethyl Corporation in the United States.

Production of mogas in Ontario (both leaded and unleaded) was just over 11 billion litres in 1988, while production of avgas (all leaded) was only 3.3 million litres. By 1997, mogas production in Ontario remained at about 11 billion litres (now all unleaded), while avgas production had virtually ceased.

As a result of the ban on lead in motor gasoline and the increase in use of catalytic converters in cars, only two refineries in Canada continue to produce leaded gasoline (all of it avgas), one in Edmonton and one in Montreal.[11] Table 1 shows the sales of Tetraethyl Lead to Canadian refineries, and Table 2 shows the production of avgas in Canada and Ontario. The drop in alkyl lead consumption can be correlated to a decrease in sales of TEL to Canada as seen in Table 1 and the corresponding Chart 1. Only avgas is shown in Table 2 because production of avgas is the principal remaining use of TEL.

---

7 Based on telephone interviews with Mr. Roger Venable, Ethyl Corporation, and Mr. Bob Larbey, Associated Octel.

8 Putnam, D.L. *Sources, Releases and Loading – Preliminary Estimates for COA Substances*. Report prepared for Environment Canada. May 1995.

9 Putnam, D.L. *Sources, Releases and Loading – Preliminary Estimates for COA Substances*. Report prepared for Environment Canada. May 1995.

10 Telephone interviews with Mr. Gordon Wilson, Ethyl Canada, and Mr. Roger Venable, Ethyl Corporation in October 1998.

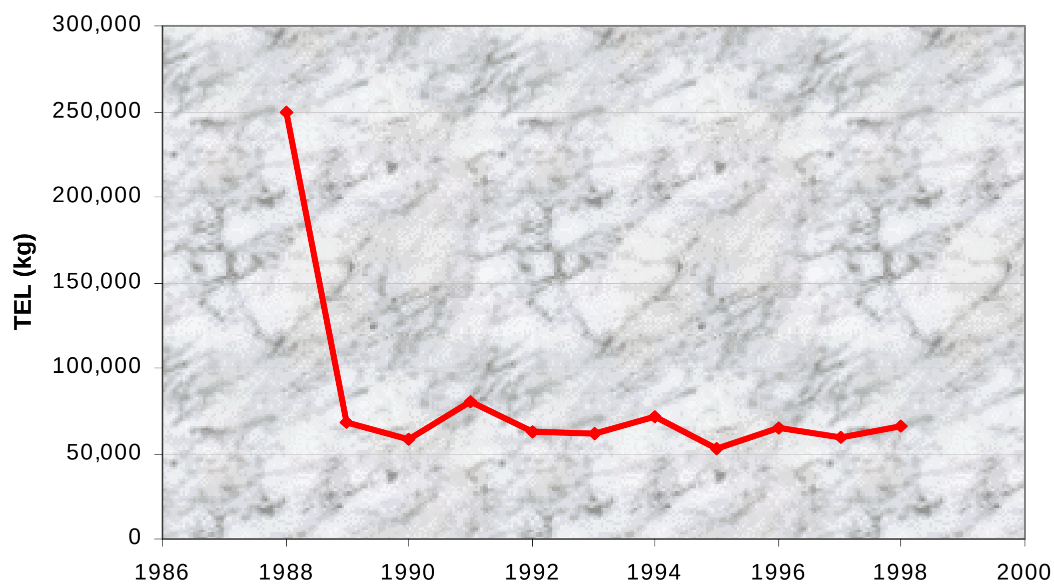
11 This statement is based on discussions with Mr. Brad Mathoney, Imperial Oil; Mr. Roger Venable, Ethyl Corporation; and Ms. Gail Bolubash, CPPI; all of whom agreed that all leaded gasoline produced is avgas. The type of avgas produced is 100LL, with a maximum lead concentration of 560 mg/L.

TABLE 1 — SALES OF TETRAETHYL LEAD TO CANADIAN REFINERIES[12]

Year	Anti Knock Compound (kg)	Tetraethyl Lead (kg)
1988	406,000	249,650
1989	110,000	67,600
1990	94,000	57,800
1991	130,000	79,900
1992	101,000	62,100
1993	100,000	61,500
1994	116,000	71,300
1995	85,000	52,300
1996	97,000	59,600
1997	97,000	59,600
1998 (estimate)	107,000	65,800

Table 1 shows a 74% decline in TEL sold to Canadian refineries between 1988 and 1997. This probably underestimates the decline, as the coming elimination of leaded motor gasoline in 1990 was known in advance. It is therefore likely that the figures for 1988 and 1989 already understated the use of TEL as stockpiles sold prior to 1988 were drawn down by refiners. The drop in TEL sold to Canadian refiners is also shown in Chart 1.

Chart 1 — Sales of Tetraethyl Lead to Canadian Refiners



Source: Ethyl Corporation

---

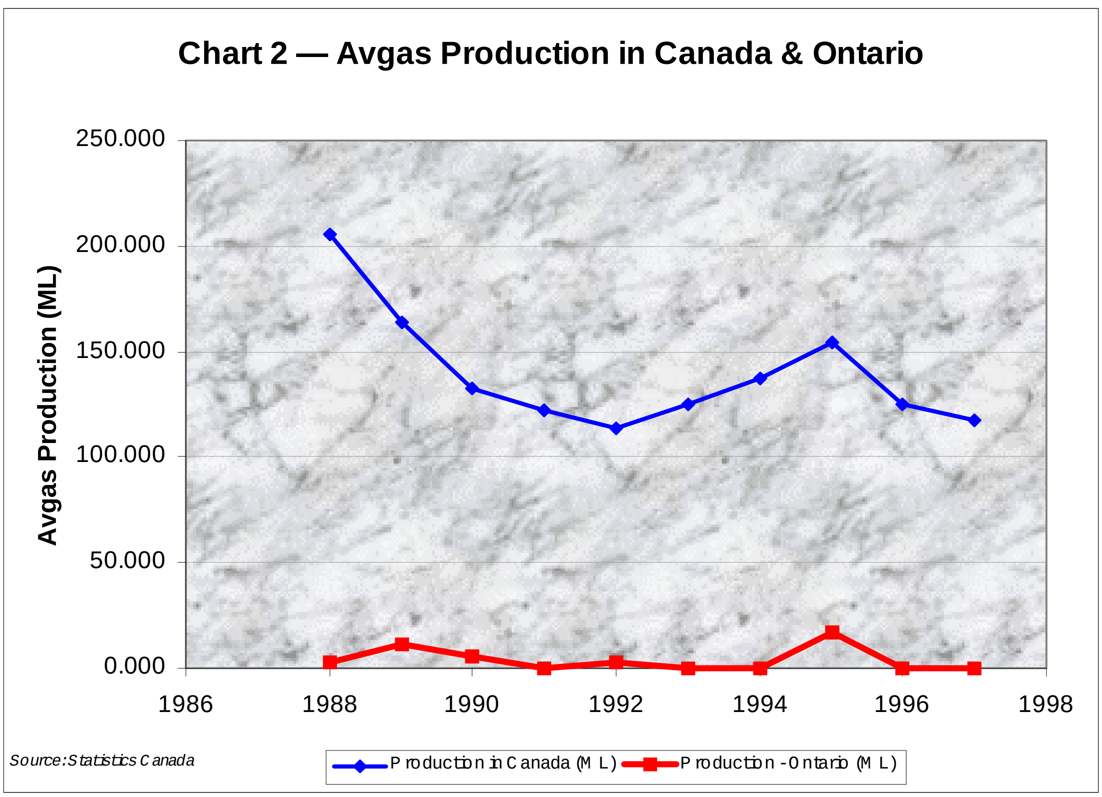
12 Letter from, and telephone interview with, Mr. Roger Venable, Ethyl Corporation. Anti Knock Compound (aviation mix) contains 61.49% TEL by weight. MMT is not included in this formulation.

TABLE 2 — AVGAS PRODUCTION IN CANADA AND ONTARIO[13]

Year	Production - Canada (ML)	Production - Ontario (ML)	Production - Other (ML)	Ontario as Percent of Canada
1988	205.204	3.303	201.901	2%
1989	163.801	11.200	152.601	7%
1990	132.405	5.371	127.034	4%
1991	122.319	0.033	122.286	0%
1992	113.391	2.409	110.982	2%
1993	124.644	0.000	124.644	0%
1994	137.642	0.466	137.176	0%
1995	154.691	17.035	137.656	11%
1996	125.389	0.002	125.387	0%
1997	117.431	0.027[a]	117.404	0%

[a] Confirmed with Statistics Canada that the 0.027 ML reported in 1997 is a reporting error and that production in 1997 was zero.

Table 2 illustrates that, in the last ten years, avgas has been produced outside Ontario for the most part. The spike of production in 1995 appears to be an aberration from the normal pattern. This is graphically shown in Chart 2.



[13] Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB. Various years.

4.0 USES OF ALKYL LEAD

4.1 Overview

One of the most important determinants of thermodynamic efficiency in an internal combustion engine is its compression ratio[14]. The compression ratio is the ratio of the maximum to the minimum volume in the cylinder of an internal combustion engine. The ability of engine designers to increase the compression ratio depends on the fuel's resistance to auto-ignition; this resistance is measured using an index called "octane".

Adding alkyl lead is the most cost-effective means of achieving higher octane in gasoline. For high compression engines, this octane boost is required to avoid auto-ignition. Auto-ignition is the spontaneous ignition of the air-fuel mixture inside the combustion chamber prior to the presence of the spark intended to ignite the mixture. The consequences of auto-ignition are power loss, increased fuel consumption, higher emissions, and potentially engine damage (even destruction).

Prior to 1970, lead in the fuel acted both as an octane booster and as a lubricant for engine valves and valve seats. Since the introduction of unleaded fuel in the mid-1970s, valve seats or inserts have been made from a hardened material that no longer requires this protection. In the mid-1970s, with the increasing focus on reducing motor vehicle emissions, catalytic converters were introduced to reduce tailpipe emissions. Catalytic converters and leaded fuel cannot coexist because lead builds up in the catalytic converter, preventing removal of harmful tailpipe emissions.

When lead was banned in 1990, there was considerable concern that older vehicles, particularly classic cars, would experience engine damage with unleaded fuel since there would no longer be any protection for the valves and valve seats. Classic car owners have found that their concerns were unfounded. This was confirmed in telephone interviews with Mr. Murray McEwan of *Old Autos* and Mr. Peter Taylor of *Power Boating in Canada*, who both noted that the issue essentially no longer comes up in articles and letters.[15] In addition, some "octane enhancers" and "lead substitutes" not containing alkyl lead are available on the market.

On-road testing was conducted with numerous public sector and private utilities' vehicles in 1986. It was found that little valve-seat recession occurred in normal use.

---

14 Amann, C.A. "The stretch for passenger car fuel economy: a critical look. Part I." *Automotive Engineering International*. SAE February 1998.

15 Interviews with Murray McEwan, *Old Autos*, and Peter Taylor, *Power Boating in Canada*, editors of classic car and boating magazines, both of whom indicated that the earlier concerns about engine damage from unleaded fuel were no longer a subject of discussion in their magazines.

Weaver (1986) stated "In summary, the potentially detrimental effects of eliminating leaded gasoline appear to have been greatly exaggerated in the public mind, while the potentially beneficial effects have been either understated or ignored."[16]

The regulations[17] to ban the use of lead in gasoline were introduced under the *Canadian Environmental Protection Act* in 1990, with a few defined exemptions. The main exemption was aviation gasoline, which was not considered "gasoline" under the Regulations. Other exemptions include:

- tractors, combines, and swathers or any other machinery used in farming
- boats
- trucks with Gross Vehicle Weight over 3,856 kg
- competition vehicles[18]

Leaded gasoline use in Ontario has declined from about 3 billion litres in 1988 to roughly 33 million litres in 1997, a decline of 98.9%. This is the difference between 1988 and 1997 leaded gasoline sales volume, divided by 1988 leaded gasoline sales volume as listed in Table 3:

$$(3{,}063.911 \text{ ML} - 33.255 \text{ ML})/3{,}063.911 \text{ ML} \quad = \quad 0.989, \text{ or } 98.9\%$$

In contrast, overall motor gasoline consumption increased from 12.7 to 13.3 billion litres during the same period.

---

16 Weaver, C.S. *The Effects of Low-Lead and Unleaded Fuels on Gasoline Engines*. SAE Paper 860090. February 1986. As a note — in this paper, the "normal" driving contemplated by Weaver does not include high speeds, high loads, and rapid acceleration.

17 Environment Canada. *Gasoline Regulations*. Extract from Canada Gazette, Part II, May 9, 1990.

18 Not initially included in the exemptions, competition vehicles were added in an amendment based on an economic assessment of the racing industry's competitive position in North America. The exemption was extended to December 31, 2002 in the most recent amendment of the *Gasoline Regulations* (April 1998).

TABLE 3 — ONTARIO GASOLINE SALES VOLUME (MILLION LITRES – ML)[19]

	Motor Gasoline								
	1	2	3	4	5	6	7	8	9
Year	Premium	Mid Grade	Regular Unleaded	Regular Leaded	Total Motor Gasoline	Leaded Premium	Total Leaded Mogas	Aviation Gasoline	Total Leaded Gasoline
1988	2,038.6	0.0	8,125.3	2,537.6	12,701.5	485.1	3,022.7	41.2	3,063.9
1989	2,390.0	0.0	9,430.5	1,150.2	12,970.7	259.8	1,410.1	38.9	1,448.9
1990	2,101.1	860.1	9,422.8	125.0	12,509.0	27.5	152.5	46.6	199.2
1991	1,923.5	788.0	9,603.1	8.5	12,323.1	0.0	8.5	28.6	37.1
1992	1,894.9	828.6	9,518.5	1.8	12,243.8	0.0	1.8	21.0	22.8
1993	1,976.0	839.4	9,663.7	1.9	12,481.0	0.0	1.9	21.7	23.6
1994	2,082.1	817.4	9,862.1	2.4	12,764.0	0.0	2.4	22.2	24.6
1995	2,007.9	756.0	10,003.5	6.2	12,773.5	0.0	6.2	25.6	31.8
1996	1,833.0	756.0	10,296.1	3.7	12,888.8	0.0	3.7	26.6	30.3
1997	1,680.4	800.3	10,862.1	6.6	13,349.4	0.0	6.6	26.7	33.3

Notes

Column 1 — Premium gasoline up to 1990 includes both leaded and unleaded premium.

Column 2 — mid-grade unleaded gasoline was introduced in 1990.

Column 5 — Sum of Columns 1 – 4.

Column 6 — estimate of the amount of premium gasoline containing lead. It was assumed that this would be in the same proportion as for regular gasoline. For example, using 1988 figures, total regular gasoline is Columns 3 + 4, or 8,125.3 + 2,537.6 = 10,662.9. The proportion of leaded regular is 2,537.6/10,662.9. The proportion of leaded premium, therefore, is assumed to be (2,537.6/10,662.9) x 2,038.6 = 485.1.

Column 7 — total motor gasoline containing lead is Columns 4 + 6.

Column 8 — avgas also contains lead.

Column 9 — total leaded gasoline is the sum of leaded avgas and mogas, or Columns 7 + 8.

---

[19] Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB. Various years.

The decrease in Ontario leaded gasoline sales between 1988 and 1997 is shown in Charts 3 and 4 below, data for which are drawn from Table 3. The relatively high starting volume in 1988 tends to mask detail in Chart 3. Chart 4, which contains identical information to Chart 3, uses a log scale to more clearly show the slopes within each grade of gasoline.

4.2 Farm Equipment

There were typically two types of farm vehicle using leaded gasoline in 1988 — tractors under 99 horsepower (hp) and combines. Tractors above 99 hp were generally diesel-powered.[20]

Lavallee and Fedoruk (1989) estimated that the average gasoline tractor would be 30 years old by the end of 1990. They estimated that at most 10% of the tractor population was at risk of valve seat recession; in other words, 90% of the gasoline-powered tractors could switch to unleaded gasoline without risking engine damage.

Lavallee and Fedoruk also reported that only diesel-powered combines had been manufactured since 1980. Although they noted a fairly substantial proportion of combines running on gasoline (between 52 and 60% of the combine population in 1986), they concluded that the gasoline-powered population was rapidly being replaced by diesel. The Canadian Farm and Industrial Equipment Institute (CFIEI), which tracks farm equipment sales, confirmed Lavallee and Fedoruk's findings. The CFIEI indicated that

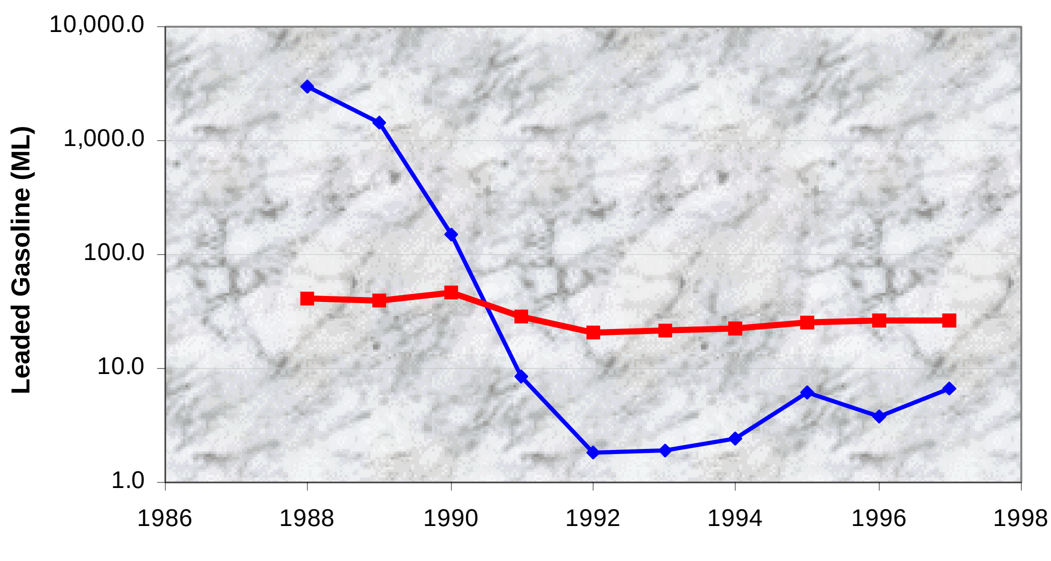
of

Chart 3 — Ontario Gasoline Sales Volumes, 1988 - 1997

Chart 4 — Ontario Gasoline Sales Volumes, 1988 - 1997
Log Scale

to

n



Source: Statistics Canada

Table 4 — Ontario Farm Energy Use (ML)[22]

	Gasoline 1981	Gasoline 1996	Diesel 1981	Diesel 1996
Farm Use	241.570	148.749	258.895	262.073
Personal Use	54.620	71.034	1.387	46.757
Total Use	296.190	219.783	260.282	308.830

In Table 3, it was shown that the total reported leaded mogas consumption for Ontario in 1996 was 3.7 million litres for all uses[23] other than avgas. It is probable that most of the 148.7 million litres of gasoline reported for farm use in Table 4 was unleaded fuel.

4.3 Competition Vehicles

Competition vehicles were added as an exemption from the *Gasoline Regulations* in May 1994. This amendment was based on an economic assessment of the racing industry's competitive position in North America, and has been extended to December 31, 2002 in the most recent amendment to the *Gasoline Regulations* (April 1998).

In Canada, there are about 110 racetracks hosting approximately 1,200 events per year.[24] Not all of these races use leaded fuel. The Canadian Association of Stock Car Racing (CASCAR), for example, states that many of their races use unleaded gasoline.[25] In 1997, Smith and Cunningham interviewed representatives of 12 race sanctioning bodies and 12 speedways to assess the potential economic impact of a number of regulatory options. They estimated that an average of 33% of the vehicles in the events surveyed used leaded fuel. It should be noted that their sample may overrepresent leaded fuel (drag strips, which are the principal users of leaded gasoline, represented 20-25% of the racetracks but 50% of the sample). Extrapolating the results of their survey to the 110 racetracks in Canada, Smith and Cunningham estimated that there were 550 leaded fuel events in Canada in 1996.[26]

---

22 Farm Energy Use Survey data, obtained from Mr. Maurice Korol, Agriculture and Agri-Food Canada.

23 Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB.

24 Smith, D., and Cunningham, R. *Economic Impacts of Options Considered for the Gasoline Regulations – Final Report*. Prepared for Environment Canada. October 1997.

25 Interview with Mr. Tony Novotny, CASCAR and Delaware Speedway.

26 Smith, D., and Cunningham, R. *Economic Impacts of Options Considered for the Gasoline Regulations – Final Report*. Prepared for Environment Canada. October 1997.

Conor Pacific Environmental (1997) estimated average leaded gasoline consumption per event to be 1,900 L at a drag strip, and 2,650 L at a stock car oval track. The study also estimates that a typical boat race would consume about 560 L of fuel, and a snowmobile race about 750 L.[27]

Combining the information from Smith and Cunningham and from Conor Pacific Environmental permits an estimate of the leaded gasoline consumed by competition vehicles in Canada. This information suggests that there are 550 leaded fuel events in Canada, with 25% (138 events) being drag events at 1,900 L each and 75% (412 events) being stock car events at 2,650 L each. No data are available on the number of boat and snowmobile events in Canada; it was assumed that the number of each is similar to drag events (138).

Drag events	138 events x 1,900 L/event	=	262,200 L
Stock Car events	412 events x 2,650 L/event	=	1,091,800 L
Boat events	138 events x 560 L/event	=	77,280 L
Snowmobile events	138 events x 750 L/event	=	103,500 L
			1,534,780 L

Statistics Canada reports a total of 4.9 ML of leaded gasoline sales in Canada in 1996[28]. This amount includes competition vehicles as well as other applications such as tractors, combines, and swathers or any other machinery used in farming; boats; and trucks with Gross Vehicle Weight over 3,856 kg, but not avgas.

In the most recent amendment of the *Gasoline Regulations*, effective April 1998, detailed reporting of all leaded gasoline "produced or imported for use or sale in Canada, or sold or offered for sale in Canada" for competition vehicles is required. This information is to be reported to Environment Canada annually, beginning in 1999,[29] and should clarify the very small quantities of fuel used for competition vehicles from all users.

4.4 Aviation Gasoline Market

There are essentially two different types of fuel used in the aviation industry — jet fuel and aviation gasoline. Jet fuel is used in the jet engines and turboprops that power most larger aircraft. Aviation gasoline (avgas) is used in the piston engines that power most light aircraft and some smaller commercial types of aircraft. Jet fuel contains no lead; its main components are either naphthalene or kerosene. Although the fuels are quite

---

27 Conor Pacific Environmental. *Ambient Lead Concentrations from Leaded Fuel Use at Drag and Stock Car Tracks*. Prepared for Environment Canada. December 1997.

28 Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB.

29 Environment Canada. *Regulations Amending the Gasoline Regulations*. Published in the Canada Gazette, Part II. April 15, 1998.

different in terms of energy content, a comparison of the number of litres of jet fuel and avgas consumed provides a useful indicator of the relative scale of fuel use. In Table 5 below, motor gasoline (mogas) has also been included as a yardstick. Avgas is the only one of these fuels containing alkyl lead.

TABLE 5— ONTARIO AVIATION FUEL SALES VOLUMES (ML)[30]

Year	Aviation Gasoline	Jet Fuel	Mogas
1988	41.181	1,665.417	12,701.452
1989	38.866	1,603.680	12,970.701
1990	46.639	1,423.544	12,509.027
1991	28.621	1,312.315	12,323.111
1992	21.007	1,276.540	12,243.798
1993	21.656	1,282.619	12,480.993
1994	22.202	1,344.923	12,764.027
1995	25.553	1,462.396	12,773.546
1996	26.555	1,646.368	12,888.840
1997	26.655	1,767.427	13,349.409

In 1997, total aviation fuel use in Ontario was almost 1.8 billion litres of both jet fuel and avgas. Avgas made up just 1.5% of the total aviation fuel. In comparison, of the 13.3 billion litres of motor gasoline (mogas) consumed, total aviation fuel comprised only 13.4% by volume. Relative to mogas, avgas comprised 0.2% of Ontario’s gasoline mix in 1997. Chart 5 shows the relative volumes of jet fuel and avgas, compared to mogas. To provide more detail on the lower volumes of aviation fuels, Chart 6 presents the same information using a log scale.

There are two grades of avgas: high octane (100/130) and low octane (80/87). The higher octane fuel is typically used in higher performance applications such as light commercial aircraft, where a high power to weight ratio is needed. The higher octane allows more power to be developed from a smaller size (and weight) engine than would otherwise be possible.

In the late 1980s, the high octane (100/130) avgas formulation was replaced with a formulation called 100LL (the “LL” stands for “low lead”). The 100LL avgas provides the same octane with a much lower TEL content (see Table 6). Most avgas consumed today is 100LL. A report by BATC in 1993 concluded that less than 2% of the avgas consumed in Canada was 80/87.[31]

---

30 Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB. Various years.

31 BATC. *Aviation Gasoline Trends in Canada*. Environment Canada. March 1993.

Chart 5 — Comparison of Aviation Fuels and Motor Gasoline (Ontario)

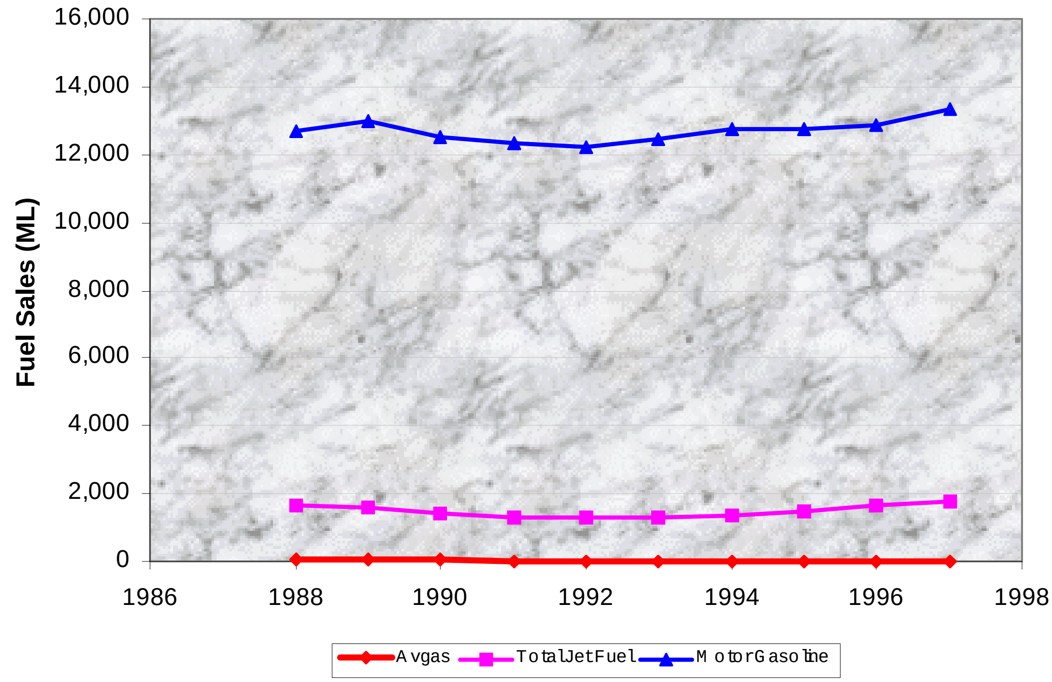
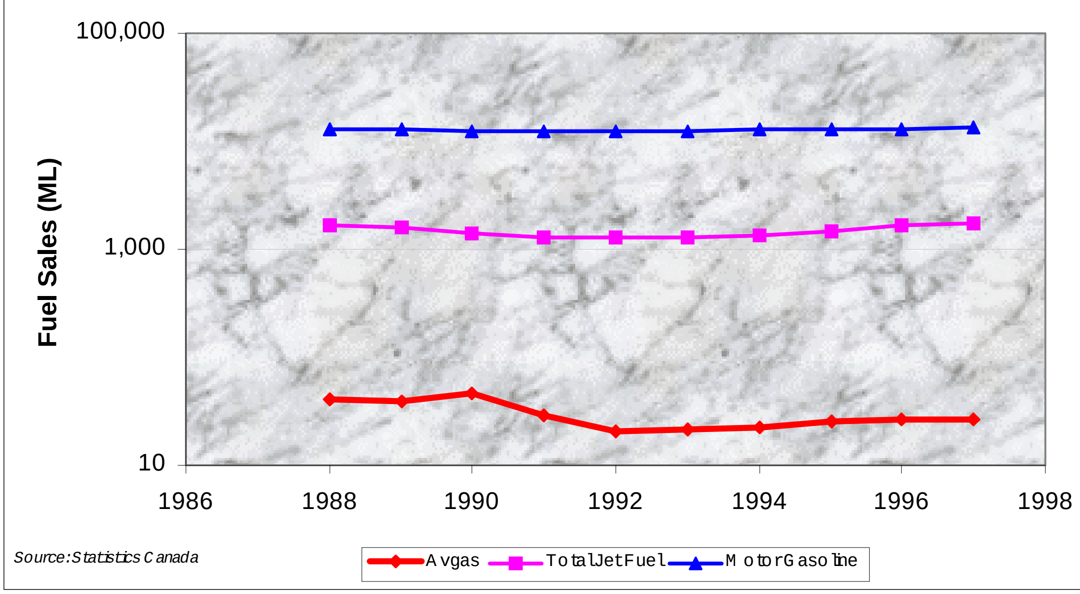


Chart 6 — Comparison of Aviation Fuels and Motor Gasoline (Ontario) (Log Scale)



In Canada, there are nineteen refineries[32] producing all grades of gasoline. Only two of these refineries produce aviation gasoline. The two refineries, one in Edmonton and the other in Montreal, produce only the 100LL grade of avgas.[33] All 80/87 avgas used in Canada is imported. No leaded gasoline is produced for any other purposes in Canada.

TABLE 6 — SUMMARY OF AVGAS TYPES

	Low Octane	High Octane	
Factor	(80/87)	(100/130)	(100LL)
TEL Content (mg/L)	140	1280	560
Colour	Red	Green	blue
Market Share	< 2%	Discontinued	> 98%

Currently, no reliable information exists on the mix of fuels used by general aviation (i.e. the split between 80/87 and 100LL). A review of the *Canada Flight Supplement* suggests that 80/87 grade avgas is more widely available than was originally believed (Appendix C). While fuel consumption data do not distinguish between grades of avgas, one airport reported sales of up to 4,000 L per week of 80/87 in peak flying season.[34] One fuel wholesaler, Graham Energy, reported bringing in 1.8 million litres of leaded fuel, believed to be 80/87 avgas, in the last year, most of which would have been sold in Ontario.[35]

Although the majority of piston-engine aircraft in service were originally certified for 80/87 avgas, they typically operate on 100LL since that is the avgas grade most generally available in Canada. These aircraft are also capable of running on mogas (with an octane of 87). Transport Canada suggests that mogas can be used safely in aircraft certified for 80/87 fuel, and may be acceptable for some aircraft certified for 100LL, as long as adequate maintenance practices are followed.[36,37] There is no information on how much mogas is currently used by light aircraft operators, but there is a price motivation to use

---

32 Canadian Petroleum Producers Institute. *CPPI: Supporting a Dialogue*. 1997 Annual Review.

33 Based on interviews with oil industry representatives, letter from Ms. Gail Bolubash, CPPI. Avgas is treated as a specialty item, with dedicated storage and trucks for transport. CPPI reports improving refinery capacity utilization from 80% to 89% over the course of this decade; this indicates a focus on productivity and implies consolidation of low volume products like avgas to achieve economies of scale.

34 Brampton airport — contacted fuel kiosk.

35 Interview with Graham Energy.

36 Interview with Mr. Peter Roberts, Powerplant and Emissions, Transport Canada.

37 Transport Canada. *The Use of Automobile Gasoline (Mogas) in Aviation*. TP 10737 Amendment 2. March 31, 1993.

it. Recent observations indicate mogas sells for between 48 and 54¢/L in the Toronto area, while avgas sells for as much as 92¢/L.[38]

While piston-engined aircraft in private or recreational applications may be able to use mogas, this is less true of commercial aircraft. Commercial carriers in categories I to III[39] accounted for the majority of all aviation fuel, and a surprisingly large proportion of avgas consumption in Canada. Data on fuel consumption by commercial carriers are available for the entire country only, and are not available on a province by province breakdown; data are also available only for the three largest categories of commercial carrier.

TABLE 7 — LEVEL I TO III COMMERCIAL CARRIERS' SHARE OF AVIATION FUEL CONSUMPTION IN CANADA[40]

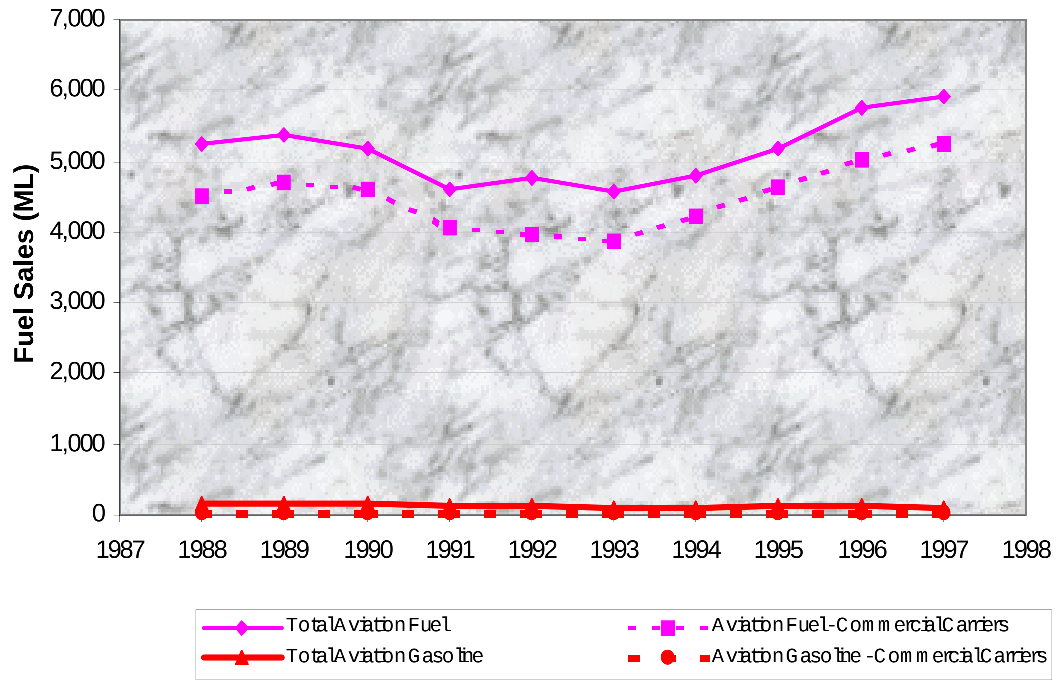
	Total Aviation Fuel, including Jet Fuel and Avgas			**Avgas only, excluding Jet Fuel**		
Year	Total Aviation Fuel	Aviation Fuel – Comm. Carriers	Comm. Carriers Share (%)	**Total Aviation Gasoline**	**Aviation Gasoline – Comm. Carriers**	**Comm. Carriers Share (%)**
1988	5,234.1	4,499.9	86.0%	**166.1**	**41.3**	**24.9%**
1989	5,355.0	4,689.2	87.6%	**162.4**	**34.1**	**21.0%**
1990	5,166.3	4,604.8	89.1%	**164.3**	**32.1**	**19.5%**
1991	4,614.2	4,065.0	88.1%	**124.7**	**27.2**	**21.8%**
1992	4,757.7	3,961.8	83.3%	**112.3**	**30.6**	**27.2%**
1993	4,556.6	3,854.4	84.6%	**111.8**	**27.2**	**24.4%**
1994	4,807.1	4,208.6	87.5%	**110.5**	**27.3**	**24.7%**
1995	5,168.7	4,642.9	89.8%	**123.4**	**24.3**	**19.7%**
1996	5,766.6	5,012.1	86.9%	**115.7**	**22.9**	**19.8%**
1997	5,914.0	5,237.5	88.6%	**110.3**	**20.7**	**18.8%**

38 Personal observation in the Toronto area in November 1998 shows mogas prices (regular unleaded) at about 48 to 54 ¢/L. Telephone calls to two local airports found avgas prices of 82 ¢/L at one and 92 ¢/L at the other. The relatively high price of avgas is a recurring theme in reports on the general aviation sector.

39 Levels I to III constitute air carriers transporting more than 5,000 revenue passengers or more than 1,000 tonnes of revenue freight annually. Levels IV through VI are much smaller, and so are more likely to operate piston-engined aircraft fuelled by avgas.

40 Data supplied by Mr. Bob Lund, Transport Canada.

Chart 7 — Commercial Share of Aviation Fuels (Canada)



Source: Statistics Canada & Transport Canada

Chart 7 shows that the avgas consumption by the three largest categories of commercial air carrier has been relatively stable, dropping off slightly in the latter part of the 1990s. This may be attributed to the increasing use of turboprop aircraft, and to subcontracting some of the low volume traffic to smaller (Level IV or V) carriers.

4.5 Airports in Ontario — Fuel Distribution

There are approximately 400 aerodromes[41] in Ontario, including private fields and water aerodromes[42] (Appendix C). In 1994, with the introduction of the *National Airports Policy,*[43] Transport Canada divested itself of almost all airports in Ontario and elsewhere in Canada. Management of these airports has devolved to local airport authorities.

Not all airports offer fuel. A review of the *Canada Flight Supplement*[44] indicates that 52% of the airports listed offer avgas, and roughly 30% of those offer both 80/87 and 100LL. At airports where avgas is available, it is commonly (but not always) contained in underground storage tanks, as it is in retail gasoline stations. Airport operators, like gasoline station operators, are expected to take regular dip measurements and determine from inventory control whether there is a problem with tank integrity.[45] In the last ten years, the petroleum industry has undergone a massive program of testing, upgrading, and replacing aged underground storage tanks at retail gasoline stations. Underground storage tanks (and some aboveground tanks) on federal land must be registered annually with Environment Canada by the owner or the appropriate federal department.[46] It is estimated that there are approximately 10,700 such storage tanks on federal lands, which include port authorities, airports, military bases, research facilities, railways, and national parks, and that as many as 5% of them may currently be leaking.[47]

As management of airports devolves to local airport authorities, any leak from a gasoline tank would be covered under various federal or provincial statutes, principal among which are the *Canadian Environmental Protection Act* and the *Ontario Environmental Protection Act*.

---

41 An aerodrome is any facility that can be used for aircraft landings and take-offs. An airport is an aerodrome that has met Transport Canada's safety and licensing standards. See Glossary (Appendix G). For the purpose of simplicity, "airport" will be used as the generic term in the body of this report.

42 Ministry of Transportation (Ontario). *Ontario Airports*. (map) 1995.

43 Transport Canada. *National Airports Policy*. July 1994.

44 Natural Resources Canada. *Canada Flight Supplement*. 13 August 1998. This is a detailed directory of aerodromes that shows location, operator, runway and radio details, and services available (including fuel). Of the 312 land aerodromes listed by MTO in its map, the *Canada Flight Supplement* shows details for 212.

45 Interviews with Mr. Ken Taylor and Ms. Anne Barker, Ontario Technical Standards and Safety Authority (TSSA).

46 Environment Canada. *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations*. Published in the Canada Gazette, Part II. January 8, 1997. The regulations came into force on August 1, 1997, and require annual reporting to Environment Canada of all underground storage tanks, and any aboveground tanks with a capacity of more than 4,000 L.

47 Environment Canada. *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations*. Published in the Canada Gazette, Part II. January 8, 1997. These figures are included in the Regulatory Impact Assessment.

Regulation of gasoline handling and registration of tanks now comes under the purview of the Ontario Technical Standards and Safety Authority (TSSA).[48] This transition is complicated by the fact that TSSA (formerly the Fuels Safety Branch of the Ontario Ministry of Consumer and Commercial Relations) is a new, quasi-independent organization with a mandate to become self-sufficient. TSSA does not make proactive inspections at airports at this time, and has no database on storage tanks at airports.

Consequently, it is unclear whether a similar program of replacement and refurbishing is required for underground storage tanks at airports. Transport Canada's Ontario Region indicated that there is no existing central database on airports other than the *Canada Flight Supplement*. It was suggested that the most likely route to find out about fuel storage at airports would be through a survey.[49] Section 5.3 contains further information on leaks.

---

48 Interviews with Mr. Alec Simpson, Transport Canada, Mr. Howard Klein, Ontario Region, Transport Canada, and Mr. Ken Taylor, Ontario TSSA.

49 Interview with Mr. Howard Klein, Transport Canada Ontario Region.

5.0 EMISSIONS

5.1 Tailpipe Emissions

Emissions of alkyl lead may occur in one of two forms: as evaporative emissions or as tailpipe emissions. A report by Putnam in 1995[50] estimated that as much as 10% of the alkyl lead in the fuel could emerge as tailpipe emissions. Others, such as Clayton et al. (1993) and Grandjean (1983), have concluded that alkyl lead immediately decomposes and associates with free radicals in the combustion chamber.[51] Clayton et al. (1993) stated that "Tailpipe or mobile source exhaust emissions have never been shown to include TEL or TML." This does not mean that no lead is in tailpipe emissions. In the 1970s, Associated Octel conducted considerable testing of vehicles in England to determine the practicality of a lead trap in the exhaust system. They determined that approximately 70% of the lead entering the engine (in the fuel) exited in the exhaust as chlorides, halides or other inorganic materials.[52] In the case of an aircraft engine, the amount of lead retained in deposits would probably be less than that for an automobile. An aircraft exhaust system is much simpler and straighter than an automobile's system. Lead deposits are proportional to the length and complexity of the route they must travel to get out. An aircraft exhaust system is much straighter and simpler than an automobile's system.

Lead emissions, other than alkyl lead, are outside the scope of this report. However, in 1997, an air and soil monitoring program conducted at two racetracks determined that lead emissions are essentially a non-issue.[53] Inhalable particulate matter (PM_{10}) measurements at 100, 500, and 1,200 m from the track were complemented by soil sampling between 300 and 1,200 m from the track. Measurements were taken during and shortly after racing in the Spring of 1997 at a straight line drag strip in Mission, BC, and a stock car track at Cornwall, Ontario. Leaded gasoline use varied between 1,900 and 2,650 litres per day at these two racing venues.

---

50 Putnam, D.L. *Sources, Releases and Loading – Preliminary Estimates for COA Substances*. Report prepared for Environment Canada. May 1995.

51 Clayton, S.K., Ramadan, W.M., and Zimmerman, D.J. *Estimation of Alkylated Lead Emissions*. Final Report, Volume 1. Prepared by TRC Environmental Corporation for the Environmental Protection Agency. September 1993. See also Grandjean, P. "Health Significance of Organolead Compounds". *Lead Versus Health*, edited by M. Rutter and R. Russell Jones. John Wiley & Sons Ltd. 1983. See also Royal Society of Canada. *Lead in the Canadian Environment: Science and Regulation. Final Report*. Commission on Lead in the Environment. September 1986.

52 Letter from Mr. Bob Larbey, Associated Octel, and follow-up telephone interview.

53 Patenaude, Lynne. *Air and Soil Monitoring of Lead at Canadian Race Tracks in May and June 1997*. Environment Canada. December 1997.

The lead concentration in soil samples was between 5 and 20 μg/kg. These concentrations are well within background levels and the Canadian Soil Quality Guidelines of 140 μg/kg. The 24-hour average of lead in the air was measured at between 0.1 and 2.1 $\mu g/m^3$, less than half of the 5 $\mu g/m^3$ Ontario guideline.[54] In extending the leaded gasoline exemption for competition vehicles to 2002, Environment Canada referenced a Health Canada conclusion that "…no measurable increase in blood lead level would occur, and that weekly lead exposures are acceptable …" near racetracks.[55]

5.2 Evaporative Emissions

Clayton et al. (1993) estimated the total evaporative emissions of TEL, from the production, transmission and utilization of avgas, at 340 kg/year in the US.[56] This corresponds to a consumption of 322,629,000 US Gallons of avgas, or 1,221.150 ML.[57] Total Ontario consumption of 26.655 ML in 1997 would imply TEL evaporative emissions in the order of 7.4 kg (calculated as 340 kg x 26.655 ML / 1,221.150 ML = 7.4 kg).

According to the Royal Society of Canada, evaporative emissions of alkyl lead are considered more of a concern in an industrial setting than in the environment. In its report on lead, the Royal Society notes that the atmospheric half-life of organolead is less than 12 hours,[58] meaning that it would decompose rapidly in the environment.

5.3 Spills and Leaks

Under the provisions of the provincial *Environmental Protection Act*, all spills must be reported to the Spills Action Centre. A review of Ontario Spills Action Centre data identified only one reported avgas spill at an airport between January 1993 and October 1998, out of a total of almost 200 spills. There were five gasoline spills, two of which were reported as motor gasoline at car rental sites on the airport, and three of which *might* have been avgas.[59]

---

[54] Patenaude, Lynne. *Air and Soil Monitoring of Lead at Canadian Race Tracks in May and June 1997*. Environment Canada. December 1997.

[55] Environment Canada. *Regulations Amending the Gasoline Regulations*. Extract from the Canada Gazette, Part II. April 15, 1998. Reference drawn from the Regulatory Impact Analysis Statement.

[56] Clayton, S.K., Ramadan, W.M., and Zimmerman, D.J. *Estimation of Alkylated Lead Emissions*. *Final Report, Volume 1*. Prepared by TRC Environmental Corp. for the Environmental Protection Agency. September 1993.

[57] 1 US gallon = 3.785 L.

[58] Royal Society of Canada. *Lead in the Canadian Environment: Science and Regulation. Final Report*. Commission on Lead in the Environment. September 1986.

[59] Ontario Ministry of the Environment Spills Action Centre.

Leaks may occur from old underground storage tanks as they deteriorate. Section 4.5 discusses underground storage tanks at airports. While leaks from underground storage tanks *should* become obvious fairly quickly through careful inventory management, this may not be as true at an airport as it would be at a retail gasoline station because of the smaller volumes passing through the tank. Canada's 13,500 retail gasoline stations sold over 32 billion litres of gasoline in 1997, representing an average throughput of 2.4 million litres per station.[60] By contrast, if half of Canada's 726 airports sell avgas, that works out to an average throughput of only 304,400 litres.[61] In Ontario, just over 100 airports offer fuel for sale (see Appendix C). Based on Ontario's avgas sales of 26.655 ML, this implies an average throughput of 240,000 L per year per airport. However, this average masks the difference in throughput between a busy airport like Toronto-Buttonville, which reported 66,363 movements of piston-engined aircraft in 1997, and one like Kenora, which reported only 4,067 such movements.[62] Given the relatively low throughput of avgas at many airports, small leaks may escape notice.

Environment Canada has established regulations requiring registration of storage tanks on federal lands. They estimate that 5% of the storage tank systems on federal lands are presently leaking petroleum or allied petroleum products.[63] Environment Canada estimates that a single litre of gasoline can contaminate a million litres of groundwater, and that this contamination may not be noticed for some time.[64]

---

60 The number of retail gasoline stations was taken from the Canadian Petroleum Products Institute 1997 Annual Review, while the retail gasoline sales are reported in Statistics Canada's *Refined Petroleum Products*, Catalogue 45-004-XPB. The average of 32,423,092,000 litres divided by 13,500 stations masks the variability between a station in a large city centre and one in a rural area.

61 The Transport Canada *National Airports Policy* cites 2,000 aerodromes in Canada, only 726 of which are certified as airports by Transport Canada. A review of the Ontario airports listed in the *Canada Flight Supplement* indicated that 52% offer fuel on site. The total volume of avgas is drawn from Statistics Canada's *Refined Petroleum Products*, Catalogue 45-004-XPB.

62 Transport Canada. *Aircraft Movement Statistics. Annual Report, 1997*. TP 577. Published by the Aviation Statistics Centre. March 1998.

63 Environment Canada. *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations*. Published in the Canada Gazette, Part II. January 8, 1997. The estimate of 5% leaking storage systems is referenced in the *Regulatory Impact Analysis Statement* included with the Regulations, which also identifies a total of 10,700 storage tank systems on federal lands.

64 From Environment Canada's web site. www.doe.ca/water/en/manage/poll/e_tanks.htm.

6.0 SUCCESS STORIES

6.1 Leaded Gasoline

The consumption of leaded gasoline in Ontario has dropped from over 3 billion litres in 1988 to just over 33 million litres in 1997, a decline of 98.9%. The concern over the potentially adverse effect of unleaded gasoline on valves and valve seats designed to operate on leaded gasoline has proved unfounded; boats, classic cars, and farm equipment have proved to operate satisfactorily on unleaded gasoline.

Ontario has met and exceeded the challenge of a 90% reduction in alkyl lead consumption since 1988.

Unleaded 100 Octane Aviation Gasoline

Finding a replacement for leaded avgas has proved problematic. Achieving the necessary 100 octane, without the use of tetraethyl lead, is extremely difficult within the bounds of economic reality.

Texaco, under the auspices of the American Society of Testing and Materials (ASTM), is continuing to develop a high octane avgas that contains no lead. There are business challenges, as well as technical challenges, to be met. For this fuel to be a successful alternative to leaded avgas, it will have to be approved for use in existing and future aircraft and to be comparable in price to avgas while allowing recouping of developmental, production, and distribution costs.[65] There is still a long way to go before commercialization, but encouraging progress has been made in solving technical problems.

---

[65] Presentation by Joe Valentine and Ken Scott, Texaco, at the Binational Toxics Strategy Working Group meeting in Chicago on November 16, 1998. Messrs. Valentine and Scott emphasized the technical difficulties still to be overcome in the research, the business issues to be managed in establishing a new fuel standard based on one company's research, and the complexity of engine and airframe certification issues that would follow introduction of a new fuel.

6.3 General Aviation Fuel

Many of the general aviation aircraft that were certified to run on 80/87 avgas have been granted Supplementary Type Certificates to operate on unleaded motor gasoline (mogas). Since regular mogas has an octane of 87, it is normally sufficient for most recreational flying.

Transport Canada, which generally accepts Supplementary Type Certificates granted by the FAA, has also published a manual listing a large number of aircraft for which mogas is an acceptable fuel. It states that aircraft certified to operate on 80/87 avgas, with a compression ratio of 7.65 or less, may consider using mogas, with the caveat that fuel containing alcohol (other than trace amounts for de-icing) is to be avoided.[66]

The Experimental Aircraft Association (EAA) reports that the ASTM has cleared the way for production of a new grade of 82 octane unleaded avgas, which may reduce fuel costs for general aviation pilots. The EAA plans to seek FAA approval to use the new fuel in aircraft with mogas Supplementary Type Certificates.[67]

The EAA (www.eaa.org) did not have any easily accessible information on ethanol.

6.4 Other Sectors

Success stories from other sectors have proved to be hard to find, because alkyl lead uses outside of avgas are insignificant. In a way, the lack of such chemical or industrial uses is the success story.

---

[66] Transport Canada. *The Use of Automobile Gasoline (Mogas) in Aviation*. TP 10737. Amendment 2, March 31, 1993.

[67] EAA News Release. “New Grade 82 Unleaded Avfuel Ready for Production”. Obtained from the EAA web site at www.eaa.org.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The Canadian Challenge of reducing alkyl lead use by 90% between 1988 and 2000 has been exceeded. By 1997, leaded gasoline consumption had been reduced by almost 99%. Of the remaining permitted uses, most are continuing to decline with the exception of aviation gasoline.

Aviation gasoline (avgas) is used in piston engines for light commercial and recreational applications. There is limited scope for replacement of leaded avgas in commercial aircraft because the octane requirement is not easily met by any means other than tetraethyl lead (TEL). Without the octane supplied by TEL, aircraft engines under full load are subject to auto-ignition, which causes power loss and potentially engine failure. An aircraft taking off with a full load of passengers or freight would stand a substantial risk of crashing if this were to occur.

Some recreational aircraft are able to operate on the lower octane unleaded mogas. Many of these aircraft may already be doing so, since the price difference is roughly 30¢/L — a substantial incentive. There is no current information on how much mogas is actually being used by light aircraft.

Transport Canada recognizes Supplemental Type Certificates granted by the Federal Aviation Authority (FAA), and has its own unleaded fuel program. EAA is working toward extending this approval to a new 82 octane unleaded avgas.

The number, age, and condition of underground fuel storage tanks at airports are unknown. Just over 100 of Ontario’s 300 land aerodromes have fuel storage facilities. Jurisdiction over these facilities is shared among federal and provincial governments, and among transportation, environment, and natural resources ministries. Environment Canada estimates that 5% of petroleum product storage systems on federal lands are leaking, and there is no reason to believe that the general population of storage systems at airports is any different.

Tailpipe emissions of alkyl lead are not a concern. The alkyl lead is virtually completely converted to inorganic forms in the combustion chamber.

Evaporative emissions of alkyl lead are in the order of 7.4 kg per year in Ontario. With an atmospheric half-life of less than 12 hours, evaporative emissions of alkyl lead are not considered an environmental problem.

Spills involving avgas, reported to the Ontario Spills Action Centre, are minimal. There was only one reported avgas spill out of roughly 200 substance spills at airports between January 1993 and October 1998.

Development of an unleaded high octane avgas (to replace 100LL) is ongoing. There remain technical and environmental issues; for example, determining that the alternative to alkyl lead is more environmentally benign than the substance it is replacing. There are also substantial business challenges related to the widespread introduction of the new fuel, and obtaining necessary engine and airframe recertification. This process could require a further eight to ten years.[68]

7.2 Recommendations

It is recommended that an inventory of fuel storage facilities at Ontario airports be undertaken. This inventory should mirror the registration requirements published in the *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products* under CEPA. This inventory could be undertaken as a joint federal-provincial project.

It would be useful to conduct a small survey to give an indication of the fuel mix currently in use by general aviation aircraft. This could update the BATC report on the amount of 80/87 avgas, and could also indicate how much mogas is being used to fuel light aircraft.

Federal/Provincial jurisdiction is unclear at airports in Ontario. It would be useful to determine the level of monitoring and enforcement at airports under provincial regulations, and to review the relative application of federal and provincial tank registration requirements.

Some measurements have been conducted of lead content in the soil and air near racetracks. It would be useful to conduct similar measurements near small airports when there are aircraft in the circuit to determine the level of exposure to inorganic lead. It is recommended that such measurements be pursued at Montreal/St Hubert, Toronto-Buttonville, and Victoria International, which are the three busiest airports in Canada for piston-engined aircraft movements.[69]

---

68 Presentation by Joe Valentine and Ken Scott, Texaco, at the Binational Toxics Strategy Working Group meeting in Chicago on November 16, 1998.

69 Transport Canada. *Aircraft Movement Statistics. Annual Report 1997*. TP 577, published by the Aviation Statistics Centre. March 1998. These three airports all had over 60,000 piston aircraft movements (a “movement” is a take-off or a landing).

It is recommended that the current work to develop an unleaded, high octane avgas be encouraged and monitored by Environment Canada.

It is recommended that there be no effort to mandate elimination of leaded avgas at this time until a feasible alternative has been found.

A P P E N D I C E S

APPENDIX A — CONTACTS

Last	First	Organization
Alexander	Eric	Canadian Chemical Producers Association
Barker	Anne	Ontario Technical Standards & Safety Authority (TSSA)
Bolubash	Gail	CPPI - Ontario Div.
Brien	Tedd	Environment Canada
Burchell	Mike	Statistics Canada
Chartrand	Denis	Statistics Canada
Digney	Rod	Transport Canada
Dore	Dominique	Environment Canada
Exeter	Joycelyn	Natural Resources Canada
Extence	Sandra	Revenue Canada
Falkiner	Bob	Imperial Oil
Graham	Jane	Graham Energy
Granger	David	The Guild
Gray	Bill	Revenue Canada
Hamre	Brent	Canadian Farm & Industrial Equipment Institute
Hogg	Darryl	Ontario Ministry of Environment
Holsclaw	Curtis	Federal Aviation Authority
Kane	Garth	Power Boating in Canada
Klein	Howard	Transport Canada
Korol	Maurice	Agriculture & Agri-Food Canada
Larbey	Bob	Associated Octel (England)
Lawson	John	Transport Canada
Lund	Bob	Statistics Canada
Lynch	Ned	Environment Canada
Mander	Bill	Environment Canada
Marty	Nick	Natural Resources Canada
Mathoney	Brad	Imperial Oil
McEwan	Murray	Old Autos Magazine
Miller	Philip	Canadian General Standards Board
Mitchell	Bruce	Ontario Ministry of Finance
Novotny	Tony	CASCAR
O'Connor	Gerry	Statistics Canada
Pierce	Bennett	Battelle
Platts	John	Transport Canada
Puckett	Keith	Environment Canada
Roberts	Peter	Transport Canada
Ross	John	Transport Canada
Scott	Ken	Texaco
Simpson	Alec	Transport Canada
Strader	Evelyn	Council of Great Lakes Industries
Tasler	Peter	Power Boating in Canada
Taylor	Ken	Technical Standards & SafetyAuthority (TSSA)
Tharby	Ron	Canadian General Standards Board
Tron	John	Ontario Ministry of Transportation
Turnbull	Dave	Transport Canada
Valentine	Joe	Texaco
Venable	Roger	Ethyl Corporation
Wilson	Gord	Ethyl Canada

APPENDIX B — REFERENCES

Agriculture and Agri-Food Canada and Statistics Canada. *Economic Overview of Farm Incomes*. SC CAT 21-005-XIE Vol. 1, Number 1. October 1998.

Amann, C.A. “The stretch for passenger car fuel economy: a critical look. Part I.” *Automotive Engineering International*. SAE February 1998.

Andrews, Daniel and Neville, Christine. *Scientific Criteria Document for the Development of Provincial Water Quality Guidelines for Alkylleads*. Ontario Ministry of Environment & Energy. July 1993.

BATC. *Aviation Gasoline Trends in Canada*. Environment Canada. March 1993.

Blake, Cassels & Graydon. *Lex Mundi: A Lawyer’s Guide to Canada*. A paper on environmental law accessed via the Internet.

Canada – USA. *The Great Lakes Binational Toxics Strategy – Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes*. Undated.

Canadian Chemical Producers’ Association. *Reducing Emissions 4 — 1995 Emissions Inventory and Five-Year Projections*. Accessed via Internet at www.ccpa.ca/Reports/1996/nerm/Nerm.htm.

Canadian Petroleum Products Institute. *CPPI: Supporting a Dialogue. 1997 Annual Review*. December 1997.

Canadian Petroleum Products Institute. *First Environmental Performance Review*. Undated.

Clayton, S.K., Ramadan, W.M., and Zimmerman, D.J. *Estimation of Alkylated Lead Emissions*. Final Report, Volume I. Prepared by TRC Environmental Corporation for the Environmental Protection Agency. September 1993.

Clayton, S.K., Ramadan, W.M., and Zimmerman, D.J. *Estimation of Alkylated Lead Emissions*. Final Report, Volume II – Appendices A - T. Prepared by TRC Environmental Corporation for the Environmental Protection Agency. September 1993.

Conor Pacific Environmental. *Ambient Lead Concentrations from Leaded Fuel Use at Drag and Stock Car Tracks*. Prepared for Environment Canada. December 1997.

Environment Canada. *Gasoline Regulations*. Extract from Canada Gazette, Part II, May 9, 1990.

Environment Canada. *National Pollutant Release Inventory — Summary Report 1996*. Catalogue En40-495/1-1996E.

Environment Canada. *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations*. Published in the Canada Gazette, Part II. January 8, 1997.

Environment Canada. *Regulations Amending the Gasoline Regulations*. Extract from the Canada Gazette, Part II. April 15, 1998.

Environmental Protection Agency (US). *1990 Emissions Inventory of Section 112 (c) (6) Pollutants — Final Report*. April 1998. Accessed via Internet, but only the report body and Appendix B (which referenced alkyl lead) were downloaded.

Experimental Aircraft Association. *Automobile Fuel Program of the EAA Foundation Inc.* Accessed via the Internet.

Federal Aviation Agency. *Leaded Fuel Used in Engines and the Potential Impacts of the 1990 Amendments to the Clean Air Act on Transportation*. (undated, unattributed document apparently written in response to a letter from an unidentified person. Obtained as part of a package of information supplied by the Canadian Owners and Pilots Association).

Grandjean, P. “Health Significance of Organolead Compounds”. *Lead Versus Health*, edited by M. Rutter and R. Russell Jones. John Wiley & Sons Ltd. 1983.

Lavallee, F.C. and Fedoruk, L.P. *The Elimination of Leaded Motor Gasoline: The Effect on Canadian Gasoline Engines Beyond 1990*. Environment Canada Report EPS 3/TS/1. October 1989.

Ministry of Transportation (Ontario). *Ontario Airports*. (map) 1995.

Natural Resources Canada. *Canada Flight Supplement*. 13 August 1998.

Natural Resources Canada. *Canada’s Energy Outlook, 1996 – 2020*. April 1997.

Natural Resources Canada. *Energy Efficiency Trends in Canada, 1990 – 1996*. June 1998.

Osler, Hoskin & Harcourt. *Doing Business in Canada*. A paper on environmental law accessed via the Internet at www.osle.com/Reosources/dboenv.html.

Patenaude, Lynne. *Air and Soil Monitoring of Lead at Canadian Race Tracks in May and June 1997*. Environment Canada. December 1997.

Pendleton, P.O. *Automotive Gasoline Usage in Reciprocating Aircraft Engines*. SAE Paper 871012. April 1987.

Putnam, D.L. Sources, Releases and Loading – Preliminary Estimates for COA Substances. Report prepared for Environment Canada. May 1995.

Royal Society of Canada. *Lead in the Canadian Environment: Science and Regulation. Final Report*. Commission on Lead in the Environment. September 1986.

Smith, D., and Cunningham, R. *Economic Impacts of Options Considered for the Gasoline Regulations – Final Report*. Prepared for Environment Canada. October 1997.

Statistics Canada. *Aviation in Canada*. Catalogue 51-501E Occasional. October 1993.

Statistics Canada. *Farming Facts 1997 – Statistical Insights on Canadian Agriculture*. SC CAT 21-522-XPE. February 1998.

Statistics Canada. *Refined Petroleum Products*. Catalogue 45-004-XPB. December 1997 (including year-to-date). March 1998.

Transport Canada. *Aircraft Movement Statistics. Annual Report, 1997*. TP 577. Published by the Aviation Statistics Centre. March 1998.

Transport Canada. *Canadian Civil Aircraft Register*. Accessed via the Internet.

Transport Canada. *National Airports Policy*. July 1994.

Transport Canada. *The Use of Automobile Gasoline (Mogas) in Aviation*. TP 10737 Amendment 2. March 31, 1993.

Valentine, Dorn, Studzinski, Liiva, Firmstone, and Campbell. *Developing a High Octane Unleaded Aviation Gasoline*. SAE Paper 971496. May 1997.

Van Horne Institute. *Aviation Fuel Tax Study* – Chapter IV – Federal Excise Tax on Aviation Fuel. Accessed via the Internet at www.atac.ca/fueltax/fueltax4.html.

Watson, H.C., Milkins, E.E., Lansell, S., and Challenger, K. *A Before and After Study of the Change to Unleaded Gasoline – Test Results from EPA and Other Cycles*. SAE Paper 900150. February 1990.

Weaver, C.S. *The Effects of Low-Lead and Unleaded Fuels on Gasoline Engines*. SAE Paper 860090. February 1986.

Weir & Foulds. *Environmental Law*. Summary of Canadian environmental law accessed via the Internet.

Zeisloft, H. *Autogas Flight Test in a Cessna 150 Airplane*. SAE Paper 830706. April 1983.

APPENDIX C — ONTARIO AIRPORTS

The following data comprises a comparison of a map of Ontario aerodromes, published by the Ontario Ministry of Transportation, with the Ontario aerodromes listed in the *Canada Flight Supplement*. This comparison was complicated by the relative dates — the Ontario map was last updated in 1995, while the *Canada Flight Supplement* used was the August 1998 edition. Some aerodromes have changed operators in the meantime, and the names used are not entirely consistent.

The fuel availability in the comments column is drawn from the *Canada Flight Supplement*. This information is somewhat unclear, however — the CFS lists two types of 100 octane fuel as being potentially available, 100LL (blue) and 100/130 (green). Other sources indicate that 100/130 (green) has not been available in Canada since 1989. Some airports list 100LL, some list 100 — in completing the table, it has been assumed that all 100 octane fuel is actually 100LL, and the confusion arises from reporting error.

TABLE A1 — SUMMARY OF AVGAS AVAILABILITY

Item	Number
Total land aerodromes (MTO)	312
Ontario aerodromes listed by CFS	212
Number of locations with avgas	111
Only 80/87 grade avgas	8
Only 100 grade avgas	70
Both 80/87 and 100LL	33

TABLE A2 — LIST OF LAND AERODROMES IN ONTARIO

Airport Name	Phone	Operator	Comments/Avgas Available
Alexandria	613-525-3247	Alexandria Aviation Ltd.	80
Alliston	705-435-3175	A. Murphy	
Alvinston	519-847-5359	K. Ferguson	not listed in CFS
Angling L./Wapakeka	807-473-2000	Ontario	
Armstrong	807-473-2000	Ontario	
Arnprior/Colbert	613-623-7071	E. B. Colbert	not listed in CFS
Arnprior/South	613-623-9687	S.Renfrew Muni.Arprt.Comm.	80, 100
Arnstein	705-757-2050	Rogerson's Resort	
Arthur East	519-848-3621	York Soaring Assoc.	
Arthur North	519-848-3821	L. Kallio	80, 100
Atikokan Municipal	807-597-6582	Township of Atikokan	100
Atikokan/Crystal Lake	807-597-6971	Ont. Min. of Natural Resources	not listed in CFS
Attawapiskat	807-473-2000	Ontario	
Atwood	519-356-9077	B. & C. Poelstra	100
Ayr/Sage	519-621-4460	E. and E. Sage	not listed in CFS
Ayton	519-665-7647	B. Lemke	not listed in CFS
Baldwin	905-722-5364	Toronto Aerosport	
Bancroft	613-332-1446	Bancroft Flying Club	
Bar River	705-248-2158	Springer Aerospace Ltd.	100
Barrie Exec. Airpark	705-721-3322	Barrie Flight Centre	100
Barrie-Orillia	705-487-0999	Lake Simcoe Rgnl Arpt Comm	100 - not listed on MTO map
Barry's Bay	613-756-2045	Dr. A. H. Chapeskie	
Beachburg	613-582-3305	W. Buchanan	not listed in CFS
Bearbrook	613-835-2792	T. C. Smith	not listed in CFS
Bearskin Lake	807-473-2000	Ontario	
Beeton/Brouwer	705-435-5252	J. Brouwer	not listed in CFS
Belleville	613-968-6504	J. Marker	100
Belton	519-349-2641	R. Rader & W. Weir	not listed in CFS
Bewdley/Morton	905-797-2958	N. Morton	not listed in CFS
Big Trout Lake	807-473-2000	Ontario	
Blenheim	519-676-2429	H. M. Clark	
Borden	705-423-2159	DND	military
Bracebridge	705-764-1262	D. Goltz	
Bradford	905-487-0013	E. Maslak	
Brampton	905-798-7928	Brampton Flying Club	80, 100
Brantford	519-753-2521	City of Brantford	100
Brechin	705-484-5949	Tom & Eleanor Garry	not listed in CFS
Bright's Grove/Carters	519-542-5921	H. Carter	not listed in CFS
Brockville	613-342-4511	Brock Air Services Ltd.	100
Brussels	519-887-6753	W. J. Armstrong	not listed in CFS
Brussels	519-887-6882	B. Van Keulen	not listed in CFS
Burlingtion Airpark	905-335-6759	V. Kovachik	100
Cambridge/Reids Field	519-658-6656	Reid's Heritage Homes Ltd.	
Campbellford	705-653-4098	F. Palmatier	
Carey Lake	705-362-5700	L. Veilleux	
Carleton Place	613-257-2878	M. MacPherson	
Carnarvon/Whistlewing	905-830-1484	J. Flicker	not listed in CFS
Carp/Bradley	613-839-5542	J. H. Bradley	100 - listed as Ottawa/Carp
Cat Lake	807-473-2000	Ontario	
Centralia/Huron Airpark	519-228-6111	Ontario Development Corp.	80, 100
Chapleau	705-864-1828	Township of Chapleau	100

Airport Name	Phone	Operator	Comments/Fuel Available
Chatham	519-676-3455	City of Chatham	100
Clinton/Dale	519-527-0284	H. Dale	not listed in CFS
Cobden/Bruce McPhail	613-432-5323	Champlain Flying Club	80
Cochrane	705-272-6500	Town of Cochrane	100
Collingwood	705-445-2663	Town of Collingwood	100
Cookstown	705-458-9229	M. Bowes	not listed in CFS
Cornwall Regional	613-931-3311	Cornwall Regional Arpt Comm	80, 100
Craighurst/Fowler	705-728-0802	H. Fowler	not listed in CFS
Culloden	519-877-2279	G. W. Cattle	
Deep River/Rolph	613-584-4576	A. H. Smith	
Deer Lake	807-473-2000	Ontario	
Dover Centre/Buttler	519-627-2367	E. A. Butler	not listed in CFS
Dresden/McBrayne	519-683-2027	A. McBrayne	not listed in CFS
Dryden Muni	807-937-4959	Town of Dryden	100
Durham (Mulock)	519-369-5100	Dr. D. Culver	
Dutton/Bobier	519-762-2486	R. Bobier	not listed in CFS
Dwight	705-635-2297	Borden Boothby	
Eagle River	807-755-2441	North Shore Lodge	
Ear Falls	807-222-3624	Township of Ear Falls	100
Earlton	705-563-2215	TC	100
Elk Lake	705-678-2312	P. Tessier	
Elliot Lake Municipal	705-461-7222	City of Elliot Lake	100
Elmira	519-669-2849	N. Kennedy	
Elmira (East)	519-669-5438	D. Hoffer	
Elmwood/Holley	519-363-3003	Ishbel Holley	not listed in CFS
Eltrut	807-468-3111	Ont. Min. of Natural Resources	not listed in CFS
Embrun	613-443-5492	Embrun Flying School/E.Berube	
Embrun/Russell	613-443-2759	Air Ottawa	not listed in CFS
Emsdale	705-636-5057	Emsdale Airport Comm	
Essex	519-776-7441	Paul & Ann Harrington	
Essex/Billings	519-723-4479	G. Billings	not listed in CFS
Ethel	519-887-6328	D. J. Martin	
Exeter/Sexmith	519-237-3386	L. Grebb	not listed in CFS
Fergus	519-843-1487	C. Juergensen	100
Fernleigh	613-479-5566	A. & L. Parkers	not listed in CFS
Fintona	705-435-5685	P. Davies	not listed in CFS
Forest/Kernohan	519-786-5540	G. Kernohan	not listed in CFS
Fort Albany	807-473-2000	Ontario	
Fort Erie	905-871-2100	Fleet Industries	
Fort Frances Muni	807-274-3930	Town of Fort Frances	100
Fort Hope	807-473-2000	Ontario	
Fort Severn	807-473-2000	Ontario	
Gananoque	613-382-8085	Gananoque Arpt. Comm.	100
Geraldton	807-854-1697	Town of Geraldton	100
Glencoe	519-287-3138	G. Simpson	not listed in CFS
Goderich	519-524-2915	Municipality	80, 100
Gore Bay/Manitoulin	705-282-2101	TC	100
Gore's Landing	905-342-2140	E. Harris	
Grand Bend	519-238-8610	Grand Bend Arpt Committee	80, 100
Grand Valley	519-925-3470	The Erin Soaring Society	80
Grand Valley/Windsong	519-855-4367	D. & D. Haws	not listed in CFS
Granton/Denfield	519-666-1859	B. Parkinson	not listed in CFS
Granton/Westman	519-225-2452	G. Westman	not listed in CFS
Greenbank	905-985-7683	Tacata Airways Ltd.	80
Grimsby Airpark	905-945-6161	R. Meyer	80, 100
Guelph	519-824-2660	Aviation Intl. (Canada) Inc.	80, 100

Airport Name	Phone	Operator	Comments/Fuel Available
Haliburton/Stanhope	705-754-2611	Township of Stanhope	80, 100
Hamilton	905-679-4151	Municipality	100
Hanover/Saugeen Mun.	519-364-3220	Town of Hanover	80, 100
Harriston/Yungblut	519-343-5843	N. Yungblut	not listed in CFS
Hawkesbury	613-632-0886	Montreal Soaring Council	
Hawkesbury (Windover Field)	514-424-1496	PFIS Avn. Inc.	
Hawkesbury East	613-632-0123	C & S Enterprises Ltd.	100
Hearst (Rene Fontane)	705-362-4341	Corp. of the Town of Hearst	100
Hensall/Elder	519-263-6142	H. Elder	not listed in CFS
Highgate	519-678-3326	R. Spence	
Highgate/Bateman	519-693-4227	R. & W. Bateman	not listed in CFS
Hillsburgh/Elliott	519-855-6476	F. C. Elliott	not listed in CFS
Hockley/Sleepy Hollow	519-941-0876	R. Burton	not listed in CFS
Holland Ctr/Glendale	519-794-3467	R. Comber	not listed in CFS
Honeywood/Springwater	705-466-2246	H. & G. Kaiser	not listed in CFS
Hornepayne Municipal	807-868-2020	Township of Hornepayne	100
Horning's Mills/Funston	519-925-6598	J. D. Funston	not listed in CFS
Horning's Mills/Leitch	519-925-6351	D. Leitch	not listed in CFS
Huntsville	705-789-6411	Deerhurst Inc.	
Ignace Municipal	807-934-2202	Township of Ignace	
Indian River	705-652-3055	C. Brown	
Iroquois	613-652-2261	Village of Iroquois	
Iroquois Falls	705-232-6435	Town of Iroquois Falls	100
Kakabeka Falls	807-935-2587	Kakabeka Falls Flying Inc	
Kapuskasing	705-335-2611	TC	100
Kars	613-489-2332	Larry Rowan	
Kasabonika	807-473-2000	Ontario	
Kashechewan	807-473-2000	Ontario	
Keene	705-295-4591	Elmhirst's Resort (Keene) Ltd.	100
Keewaywin	807-473-2081	Ontario	
Kennebec Lake	613-335-5547	Ross Baker	not listed in CFS
Kenora	807-548-5377	TC	100
Kincardine	519-396-4454	Town & Twnp Arpt Comm.	80, 100
Kincardine (Ellis Field)	519-396-3200	B. Ellis	
Kincarding/Farrel	519-395-5217	J. E. Farrel	not listed in CFS
Kingfisher Lake	807-473-2000	Ontario	
Kirkland Lake	705-567-6010	Town of Kirkland Lake	80, 100
Kirkton/Ratcliffe	519-229-6120	B. Ratcliffe	not listed in CFS
Kitchener/Waterloo	519-648-2256	Waterloo-Guelph Regional Arpt.	80, 100
Lambeth	519-652-2455	I. Pack	not listed in CFS
Lansdowne House	807-473-2000	Ontario	
Leamington/Tatomir	519-326-1929	S. Tatomir	not listed in CFS
Lefroy	705-456-3138	J. Cole	
Lindsay	705-324-8921	Lindsay Airpark Ltd.	80 ,100
Listowel	519-291-4840	R. W. Trench	
London	519-452-4015	TC	100
Long Sault	613-534-2597	Long Sault Flying Club Inc.	not listed in CFS
Lucan	519-227-4091	General Airspray Ltd.	
Manitouwadge	807-826-4041	Township of Manitouwadge	100
Manitowaning/Manitoulin East	705-859-3009	Manitoulin E Muni Arpt Com	100
Mansfield	705-435-9460	Carl & Doreen Lovett	
Marathon	807-229-1183	Town of Marathon	100
Melbourne	519-289-5961	B. Carruthers	
Midland/Huronia	705-526-8086	Huronia Airport Commission	100
Milverton	519-595-8864	T. Roulston	not listed in CFS
Miminiska	807-242-1408	Miminiska Lodge	

Airport Name	Phone	Operator	Comments/Fuel Available
Minaki	807-224-4000	Minaki Lodge	not listed in CFS
Minden/Allsaw	705-286-1217	A. Harrison	not listed in CFS
Minesing/Reaman	705-726-1989	J. Reaman	not listed in CFS
Monkton	519-347-2924	L. Partridge	not listed in CFS
Moosonee	705-336-2731	Moosonee Dvlpmt. Area Board	100
Morrisburg	613-543-3704	St. Lawrence Parks Comsn	
Mountain View	613-392-2811	DND	
Mt. Albert/Aquila Field	905-473-5210	Maureen McGraw	not listed in CFS
Muskegsagagen Lake	807-928-2766	Lac Minerals	not listed in CFS
Muskoka	705-687-2194	TC	100
Muskrat Dam	807-473-2000	Ontario	
N. Monteville Skypark	705-898-2727	Edgar Leis	80, 100
N. Woodslee/Martin	519-727-3327	V. Martin	not listed in CFS
Nakina	807-329-5919	Township of Nakina	100
Nestor Falls	807-484-2172	Community of Nestor Falls	
New Liskeard	705-647-7056	J. A. Rundle	
New Lowell	705-424-5593	Skydive Toronto Inc.	
Niagara Falls/Steven	905-295-3728	S. Barnett	not listed in CFS
Nobleton	905-859-5123	Beacon Hill Airpark Ltd.	
Nobleton/Peelar	905-859-4279	L. Peelar	not listed in CFS
North Bay	705-474-3020	TC	100
North Spirit Lake	807-473-2000	Ontario	
North Willington	519-343-5626	A. & F. Spoelstra	not listed in CFS
Norwood	705-639-2118	C. Telford	80, 100
Oakwood/West	705-953-9795	C. West	not listed in CFS
Ogoki Post	807-473-2000	Ontario	
Omemee	705-799-7812	Omemee Gliding & Country Ltd.	not listed in CFS
Orangeville/Douglas	519-941-1203	D. A. Douglas	not listed in CFS
Orangeville/Flying Cloud	519-941-2941	R. & M. Alexander	not listed in CFS
Orangeville/Murray Wesley Kot	519-941-9336	M. & K. Kot	100
Orillia (Mara)	705-327-3356	Sunlake Resources Ltd.	80, 100
Oro-Barrie-Orillia	705-487-0999	Oro-Barrie-Orillia Arpt Comsn	not listed in CFS
Oshawa	905-576-8146	Municipality	80, 100
Ottawa International	613-998-3151	TC (DND)	80, 100
Ottawa/Carp	613-839-3340	Township of W. Carleton	100
Ottawa/Rockcliffe	613-746-4425	Rockcliffe Flying Club	80, 100
Owen Sound	519-371-6936	City of Owen Sound	100
Oxford Centre/Kitchens	519-467-5346	Earlhaven Farms Ltd.	not listed in CFS
Palmerston	519-343-5626	F. Spoelstra	
Palmerston/Yungblut	519-343-2796	R. C. Yungblut	not listed in CFS
Parry Sound	705-378-2897	Georgian Bay Arpt Comsn	100
Peawanuck	807-473-2000	Ontario	100
Pelee Island	519-724-2265	D. Cowie, Arprt. Manager	
Pembroke	613-687-5300	Pembroke & Area Airpt Comm	100
Pendelton	613-673-5386	Gatineau Gliding Club	
Petawawa	613-588-5789	DND	
Peterborough	705-743-6708	City of Peterborough	100
Petrolia	519-882-2842	W. Arndt.	
Pickle Lake	807-473-2000	Ontario	
Picton	613-476-3057	Prince Edward Flying Club	
Pikangikum	807-473-2000	Ontario	
Plevna/Land O'Lakes	613-479-2625	Tomvale Air Services Ltd.	80, 100
Poplar Hill	807-473-2081	Ontario	
Port Colbourne	905-899-1528	St. Catherines Parachute Club	100
Port Elgin	519-389-5381	Town of Port Elgin	100
Port Elgin/Pryde Field	519-832-5950	B. Pryde	

Airport Name	Phone	Operator	Comments/Fuel Available
Port Perry/Utica	905-985-9701	A. Kerry	
Pottageville	416-783-4424	S. Tannenbaum	
Prospect Lake	807-727-2253	Ont. Min. of Natural Resources	not listed in CFS
Red Lake	807-735-2096	Township of Golden	100
Rockton	519-740-9328	SOSA Gliding Club	
Rockwood/Gregg	519-853-2776	A. Gregg	not listed in CFS
Rodney	519-785-0789	R. Sudicky	
Rodney/New Glasgow	519-785-0428	K. H. Schweiger	100
Roslin	613-477-2635	Farrel Farms	not listed in CFS
Round Lake	807-473-2000	Ontario	100
Sachigo Lake	807-473-2000	Ontario	
Sandy Lake	807-473-2000	Ontario	
Sanford/Harrison	905-473-2152	J. & D. Harrison	not listed in CFS
Sarnia	519-542-5775	TC	100
Sarnia (Blackwell)	519-542-2370	J. Garrison	not listed in CFS
Sauble Beach	519-422-1768	Ross Trask	not listed in CFS
Sault Ste. Marie	705-779-3031	TC	100
Savant Lake	807-274-5335	Rusty Meyers Flying Service	
Seaforth/Winthrop	519-842-3898	J. & M. Horvath	not listed in CFS
Selkirk	905-776-2147	Charles A. Cox	not listed in CFS
Selkirk	905-776-2537	V. Hare	not listed in CFS
Selkirk/Kindy	905-776-2287	D. Kindy & Sons Ltd.	not listed in CFS
Severn Bridge/Hawkins	705-689-6106	R. Hawkins	not listed in CFS
Sharon	905-478-2150	E. Goodwin	not listed in CFS
Shelbourne	519-925-2065	Charles F. & Katherine Burbank	100
Simcoe	519-426-4768	V. Borghese	
Simcoe/Dennison Field	519-426-8602	R. Dennison	
Sioux Lookout	807-737-2829	Town of Sioux Lookout	100
Slate Falls	807-473-2081	Ontario	
Smiths Falls/Montague	613-283-1148	Smiths Falls Flying Club	80, 100
South River/Sunridge	705-386-0011	Almaguin Aero Maintenance	80, 100
South Woodslee	519-975-2404	A. Goegebeur	not listed in CFS
Southampton	519-832-2070	R. J. Wilson	
Springfield	519-773-3701	Bob Plato	not listed in CFS
Springfield/Wooley	519-773-2240	E. & L. Wooley Farms	not listed in CFS
St. Catherines	905-684-7447	Niagara Districe	100
St. Joseph Island	705-246-2397	Francis A. Nelson	
St. Marys	519-229-6380	P. Simpson	not listed in CFS
St. Thomas Muni.	519-633-5866	Municipality	80, 100
St.Williams/Leedham	519-586-2600	R. Leedham	not listed in CFS
Staples	519-687-6361	G. Korn	not listed in CFS
Stirling	613-395-2360	Oak Hills Flying Club	80, 100
Stoney Creek	905-643-2568	LeLarco Farms	80, 100
Straffordville	519-866-3483	B. & W. Rycquart	
Stratford	519-272-0952	G. and A. Camden	80, 100
Stratford Municipal	519-271-4881	Corp. of the City of Stratford	80, 100
Strathroy	519-245-4725	J. Pollock	
Strathroy (Mustardville)	519-247-3401	A. Pedden	not listed in CFS
Sudbury	705-693-2514	Municipality	100
Summer Beaver	807-473-2000	Ontario	
Teeswater	519-392-6988	D. Thompqon	
Teeswater/Buttonfield	519-392-6224	D. and F. Button	not listed in CFS
Teeswater/Earl	519-335-3823	R. Earl	not listed in CFS
Terrace Bay	807-825-9303	Township of Terrace Bay	100
Thamesville/Wabash	519-692-3263	D. Wilson	not listed in CFS
Thessalon Muni	705-842-2117	Town of Thessalon	100

Airport Name	Phone	Operator	Comments/Fuel Available
Thorndale	519-461-1849	R. Rice	not listed in CFS
Thorndale/Gough	519-660-4513	G. Gough	not listed in CFS
Thunder Bay	807-577-3143	TC	100
Tilbury/Warnock	519-682-0440	C. Warnock	not listed in CFS
Tillsonburg	519-842-2929	Town of Tillsonburg	80, 100
Timmins	705-264-5805	TC	100
Tobermory	519-596-2430	Township of St. Edmunds	100
Toronto (Lester Pearson Int.)	905-676-3030	TC	100
Toronto City Centre	416-868-6942	Toronto Harbour Comsn	100
Toronto/Buttonville	905-477-8100	Toronto Airways Ltd.	100
Toronto/Downsview	416-375-3933	DeHavilland Inc.	
Toronto/Markham	905-642-4536	Markham Airport Inc.	80
Tottenham	905-939-2974	G. Volk	
Trenton	613-965-3316	DND	100
Tullamore/Tillet	905-843-2071	N. J. Little	not listed in CFS
Tyendinaga (Mohawk)	613-396-3100	First Nations Technical Institute	100
Tyrconnell	519-762-2030	J. Hentze	not listed in CFS
Uxbridge/Cupples	905-473-2247	M. Cupples	not listed in CFS
Vankleek Hill	613-525-3194	R. Renzetti	not listed in CFS
Vermilion Bay	807-227-2633	Municipality of Machin	
Wawa	705-856-7231	Michipicoten Arpt Ccl Wawa	100
Webequie	807-473-2000	Ontario	
Welland	905-735-9511	Welland-Pt.Colborne	80, 100
Werenko	807-274-5337	Ont. Min. of Natural Resources	not listed in CFS
Wheatley/Robinson	519-825-4222	J. Robinson	not listed in CFS
Wiarton	519-534-0140	TC	80, 100
Windermere	705-769-3873	H. Longhurst	
Windsor	519-969-2430	TC	80, 100
Wingham	519-357-3550	Town of Wingham	
Woodham	519-229-8771	W. Prance	not listed in CFS
Woodstock	519-539-3303	N. Beckham	80
Woodstock/Skyhaven	519-539-9232	David & Karen Guthrie	not listed in CFS
Woodville	705-439-2591	P. Ten-Westeneind	not listed in CFS
Wunnummin Lake	807-473-2000	Ontario	
Wyevale/Der Flughaven	705-322-1189	H. Boker	100
Wyoming	519-845-3236	O. Middleton	80
York	905-765-6289	Seneca Airo Club	80

APPENDIX D — AVIATION FUEL IN CANADA

Aviation in Canada includes both commercial aviation and general aviation. The commercial sector is divided into six types of carrier. Levels I through III are carriers that transport at least 5,000 revenue passengers, or carry at least 1,000 tonnes of revenue goods. Levels IV through VI are smaller carriers, generally defined by their annual revenue. General aviation is considered private flying, recreational flying, specialty flying, government aircraft, and levels IV through VI carriers.

Aviation uses a variety of fuels, only one of which includes lead. Jet fuel and turbo fuel (kerosene or naphtha types) do not contain lead. By 1990, the high octane formulation of avgas (100/130, which contained 1,280 mg/L of TEL) had been replaced by 100LL. 100LL provides the same high octane (100/130) with substantially less lead — 560 mg/L, hence the “LL” for “Low Lead”. The low octane 80/87 grade contains only 140 mg/L, one quarter of the amount in 100LL.

Avgas 100LL contains a maximum allowable concentration of 560 mg/l of alkyl lead, in this case tetraethyl lead (TEL). It is actually an “Anti Knock Compound” (AKC) that is added to the gasoline to raise its octane. This AKC also includes scavengers and dyes; Ethyl Corporation indicates that 61.49% by weight of the Anti Knock Compound (AKC) is TEL. Every 100 kg of AKC supplied represents 61.49 kg of TEL, with the remainder being scavengers and colouring agents.

The 560 mg/L represents an allowable maximum. Consequently, refineries will typically add somewhat less than that amount to ensure that they are in compliance. For the purpose of comparing TEL sales with avgas production, a 5 % safety factor is assumed so the actual TEL content would be 560 mg/L x 0.95 = 532 mg/L.

In working backward from the reported AKC sales to Canadian refiners to estimate avgas production, the number of m^3 of avgas produced is calculated as follows:

$$\frac{\text{AKC kg} \times 0.6149 \times 1000 \text{ g/kg}}{(0.532 \text{ g/L}) \times 1000 \text{ L/m}^3} = \text{avgas m}^3$$

This calculation provides a useful check on the numbers. The sales of avgas should be very close, whether calculated from the TEL content per litre or reported by Statistics Canada.

In the tables that follow, a number of different sources are used. Statistics Canada reports fuel sales in cubic metres (m^3), while Transport Canada and Natural Resources Canada provided fuel consumption figures in millions of Litres (ML). One m^3 is 1,000 L, so to convert m^3 to ML move the decimal three places to the left. As an example, 115,000 m^3 = 115.0 ML.

TABLE A3 — ESTIMATED AVGAS PRODUCTION IN CANADA

Year	AKC (kg)	TEL = AKC * 0.6149 (kg)	Estimated Avgas Production (Ethyl) (cu.m.)	Reported Avgas Production (Statistics Canada) (cu.m.)	Difference - (cu. m.)	Difference - % (Stats Can as a base)
1988	406,000	249,649	469,266	197,027	-272,239	-138%
1989	110,000	67,639	127,141	184,896	57,755	31%
1990	94,000	57,801	108,648	129,239	20,591	16%
1991	130,000	79,937	150,258	120,655	-29,603	-25%
1992	101,000	62,105	116,739	116,076	-663	-1%
1993	100,000	61,490	115,583	131,097	15,514	12%
1994	116,000	71,328	134,076	132,792	-1,284	-1%
1995	85,000	52,267	98,245	134,468	36,223	27%
1996	105,000	64,565	121,362	112,332	-9,030	-8%
1997	97,000	59,645	112,115	115,411	3,296	3%
Total	1,344,000	826,426	1,553,432	1,373,993	-179,439	-13%
Total 1990-97	828,000	509,137	957,025	992,070	35,045	4%

Source: Ethyl Corporation (AKC) and Statistics Canada (avgas production).

The very large discrepancy in 1988-89 is because there was still a large quantity of leaded mogas being produced. Considering only the period after leaded mogas was banned, 1990 and onwards, the totals compare very closely (within 4%). There is some year to year fluctuation as refiners balance supply and demand.

The figures from two independent sources are in agreement.

TABLE A4 — LARGE COMMERCIAL CARRIERS SHARE OF AVIATION FUEL CONSUMPTION IN CANADA

Year	Total Aviation Fuel (ML)	Aviation Fuel - Commercial Carriers (ML)	Commercial Carriers Share (%)	Total Aviation Gasoline (ML)	Aviation Gasoline - Commercial Carriers (ML)	Commercial Carriers Share (%)
1988	5,234.088	4,499.856	86.0%	166.026	41.284	24.9%
1989	5,354.954	4,689.205	87.6%	162.380	34.115	21.0%
1990	5,166.277	4,604.785	89.1%	164.299	32.085	19.5%
1991	4,614.156	4,064.971	88.1%	124.663	27.202	21.8%
1992	4,757.656	3,961.785	83.3%	112.265	30.572	27.2%
1993	4,556.642	3,854.421	84.6%	111.787	27.223	24.4%
1994	4,807.119	4,208.579	87.5%	110.504	27.310	24.7%

1995	5,168.679	4,642.916	89.8%	123.474	24.309	19.7%
1996	5,766.589	5,012.066	86.9%	115.772	22.949	19.8%
1997	5,913.981	5,237.545	88.6%	110.500	20.739	18.8%

Source: Statistics Canada (total aviation fuel and total avgas) and Transport Canada (commercial carriers share).

The provincial breakdown of avgas consumption (Table A5) provided by Natural Resources Canada illustrates the steady decline in consumption over the last 20 years. These numbers are from NRCan's model of energy consumption, and so don't match Statistics Canada's figures on avgas sales exactly, but they are very close.

TABLE A5 — AVIATION GASOLINE CONSUMPTION (MILLION LITRES)

Year	Atlantic	QC	ON	MB	SK	AB	BC	CANADA
1978	35.6205	33.1444	50.7160	19.8687	15.9308	30.3103	61.0680	246.5690
1979	31.7721	31.6527	50.5370	19.6301	15.7220	31.3842	62.2017	242.9590
1980	20.4057	31.5036	52.4165	23.5979	16.0203	33.1444	61.0382	238.1860
1981	13.9022	30.5788	48.2995	24.7613	16.0203	33.3234	57.1897	223.9860
1982	12.0823	22.0167	40.6025	21.2112	11.8138	29.3854	43.1683	180.1910
1983	11.6050	26.2231	41.7064	21.0024	10.8592	21.6289	41.4379	174.7310
1984	12.1122	25.5668	42.3628	21.6587	11.8437	22.8222	40.7816	177.4160
1985	12.7685	26.3425	42.8103	20.9129	11.2470	20.4356	41.8258	176.4320
1986	11.3962	23.1205	44.1527	18.6754	10.0537	17.8699	42.0943	167.3930
1987	12.8580	22.4045	44.0836	20.4654	10.5012	17.8401	48.5874	177.1780
1988	11.0084	21.2709	41.1993	19.4809	11.3365	16.6766	45.1969	166.0500
1989	10.8294	20.5444	38.5740	17.7804	11.6348	14.6181	48.2100	162.3810
1990	8.1146	25.6265	46.1814	14.9463	10.9189	15.0358	43.5561	164.2900
1991	6.9232	19.8986	28.6098	12.2912	8.3532	12.2912	36.2769	124.6720
1992	6.5334	18.5263	20.9427	11.7840	8.4129	12.4702	33.5919	112.2910
1993	6.2351	14.1408	21.6885	10.8890	8.9499	12.5298	37.3210	111.7840
1994	6.0859	11.1277	22.1659	11.4857	8.9499	14.1706	36.4558	110.5310
1995	6.5931	21.2112	25.5370	11.0382	9.9045	17.4523	31.7124	123.4490
1996	5.6683	18.6456	26.6110	9.7852	8.2041	14.8866	32.0704	115.7220
1997	5.0119	17.1539	26.6408	10.9189	8.7709	14.9463	26.9391	110.3010

Source: Natural Resources Canada

Table A6 gives a picture of the average number of aircraft in the private, commercial, and state categories, along with their reported (to Transport Canada) hours of flying. Aircraft measure fuel consumption in litres per hour, rather than litres per 100 km, so flying hours is a useful measure.

TABLE A6 — CANADIAN AIRCRAFT POPULATION AND HOURS FLOWN

		Private	Commercial	State	Total
1988	Number	11,821	4,074	259	16,154
	Hours	859,253	2,349,659	137,607	3,346,519
	Hours/Aircraft	73	577	531	207
1989	Number	12,239	4,524	282	17,045
	Hours	761,392	2,848,561	127,170	3,737,123
	Hours/Aircraft	62	630	451	219
1990	Number	11,517	4,359	245	16,121
	Hours	686,324	2,620,259	104,219	3,410,802
	Hours/Aircraft	60	601	425	212
1991	Number	11,704	4,479	272	16,455
	Hours	679,497	2,513,724	107,705	3,300,926
	Hours/Aircraft	58	561	396	201
1992	Number	12,302	4,775	277	17,354
	Hours	692,285	2,509,812	106,206	3,308,323
	Hours/Aircraft	56	526	383	191
1993	Number	12,716	4,759	267	17,742
	Hours	815,185	2,579,579	95,275	3,490,039
	Hours/Aircraft	64	542	357	197
1994	Number	12,681	4,979	280	17,940
	Hours	835,449	2,830,683	109,603	3,775,735
	Hours/Aircraft	66	569	391	210
1995	Number	12,734	4,978	251	17,963
	Hours	758,413	2,955,345	96,403	3,810,161
	Hours/Aircraft	60	594	384	212

Source: Transport Canada

APPENDIX E — ALKYL LEAD

The primary source of information on sales of alkyl lead to Canadian Refiners was Ethyl Corporation, which the Canadian Petroleum Products Institute, Canadian Chemical Producers Association, and a number of oil industry sources contacted independently agreed is the only supplier of alkyl lead in Canada. The only form of alkyl lead in use is Tetraethyl lead (TEL). At Ethyl Corporation's suggestion, Associated Octel was also contacted and supplied an estimate of TEL sales. Associated Octel is the largest producer of TEL in the world, and so maintains an overview of the global market, although they do not sell into North America.

Table A7 below compares the TEL sales reported by Ethyl Corporation to the estimates provided by Associated Octel. Also included is a calculation that takes the reported sale of avgas in Canada (Statistics Canada) and calculates an implied TEL weight from the blended volume of leaded aviation gasoline.

TABLE A7 — COMPARISON OF CANADIAN TEL SALES FROM VARIOUS SOURCES

	1	2	3	4	5	6	7
Year	Volume AKC (kg)	Tetraethyl Lead (kg)	Octel Estimate Lead (kg)	Estimated TEL based on Octel's "lead" estimate (kg)	Avgas Production from Statistics Canada (ML)	Estimated TEL at 532 mg/L - 5% safety factor (kg)	Estimated TEL at 504 mg/L - 10% safety factor (kg)
1988	406000	249,649			205.204	109,169	103,423
1989	110000	67,639			163.801	87,142	82,556
1990	94,000	57,801	610,000		132.405	70,439	66,732
1991	130,000	79,937	410,000		122.319	65,074	61,649
1992	101,000	62,105	20,000	31,213	113.391	60,324	57,149
1993	100,000	61,490	20,000	31,213	124.644	66,311	62,821
1994	116,000	71,328	60,000	93,640	137.642	73,226	69,372
1995	85,000	52,267	50,000	78,033	154.691	82,296	77,964
1996	105,000	64,565	40,000	62,426	125.389	66,707	63,196
1997	97,000	59,645	40,000	62,426	117.431	62,473	59,185
1998	107,000	65,794	30,000	46,820	NA		
Comparative Analysis for 1992 - 1997							
Total		371,400		358,952		411,336	389,687
% Diff.				3.4%		-10.8%	-4.9%

Notes:

Relationship between Anti Knock Compound (AKC), tetraethyl lead (TEL), and elemental lead (Pb) is 61.49% of AKC is TEL, and 39.4% of AKC is Pb. For example, 100 kg of AKC includes 100 x 0.6149 = 61.49 kg of TEL. The same 100 kg of AKC contains 100 x 0.394 = 39.4 kg of Pb.

Column 1 — total Anti Knock Compound sold to Canadian Refiners, as reported by Ethyl Corporation, in kg. AKC is 61.49% TEL by weight, or 39.4% elemental lead by weight.

Column 2 — TEL reported by Ethyl Corp, calculated as column 1 x 0.6149.

Column 3 — elemental lead sold in Canada as estimated by Associated Octel. The numbers shown for 1990 and 1991 are considered anomalous as they reflect the time period of banning of leaded mogas.

Column 4 — a calculation of TEL, based on Octel's estimate. Octel's estimated elemental lead was divided by 0.394 to get weight of AKC, which was multiplied by 0.6149 to get the weight of TEL. For example, in 1992: 20,000 kg lead/0.394 = 50,761 kg of AKC. 50,761 kg of AKC x 0.6149 = 31,213 kg of TEL.

Column 5 is the avgas production for Canada, as reported by Statistics Canada.

Column 6 — estimated requirement for TEL to produce that amount of avgas, assuming TEL is added at 532 mg/L. The maximum allowable is 560 mg/L; 532 assumes a 5% safety margin to avoid going over the allowable amount (532 = 560 x 0.95).

Column 7 — a sensitivity check performs the same comparison as Column 6, except the safety margin is assumed to be 10%, and so the TEL added is 504 mg/L (504 = 560 x 0.9).

The comparative analysis at the bottom totals the amount of TEL for the years 1992 – 1997. 1992 was chosen to start because the earlier figures from Octel appeared to be anomalous. 1997 was the last year for which actual figures are available. The six-year span allows averaging out year-to-year variations caused by shifts in inventory levels. The figures provided by Ethyl Corp. are used as the baseline for comparison, so all calculations have the 1992 – 97 total for Column 2 as a base.

For example, in Column 4 – the total TEL estimated by Octel for the period 1992 – 97 was 358,952 kg. This is a difference of only 3.4% from the figures provided by Ethyl Corp. The percentage is calculated as

$$(371{,}400 - 358{,}952)/371{,}400 = 0.034, \text{ or } 3.4\%.$$

APPENDIX F — REGULATORY FRAMEWORK

Environmental management is a shared federal and provincial government responsibility, since there is no specific allocation of powers for the environment in the Canadian Constitution. Both levels of government have established *Environmental Protection Acts*, and both have legislation governing fuel storage and handling (federal *Transportation of Dangerous Goods Act*, provincial *Gasoline Handling Act*).

The Gasoline Regulations under CEPA banned the use of lead in gasoline in 1990, with a few exceptions such as aviation gasoline. These regulations have been revised regularly since then, with the most recent revision being issued in April 1998.

Underground storage tanks for gasoline and related petroleum products are generally a provincial responsibility. However, tanks on federal lands are covered by federal regulations, primarily the *Registration of Storage Tank Systems for Petroleum Products and Allied Petroleum Products on Federal Lands Regulations*.

Under Transport Canada's *National Airports Policy*, the federal government will "maintain its role as regulator but will change its current role from airport owner and operator, to that of owner and landlord." Transport Canada plans to retain ownership of the 26 airports in the National Airports System, but will lease them to Canadian Airport Authorities established for the purpose of financial and operational management. Ownership of regional, local, and other smaller airports will be transferred to local interests.

There are several excellent summaries of the existing federal and provincial available on the Internet.

http://www.ec.gc.ca/envhome.html (Environment Canada's Green Lane)

http://canada.justice.gc.ca/index_en.html (Department of Justice, Government of Canada)

http://www.wnw.gov.on.ca/ENVISION/EBR (Ontario Environmental Bill of Rights home page)

http://e-law.com/ecothoughts/ont-laws.htm (list of relevant Ontario statutes and regulations)

http://www.weirfoulds.com/business/bus13.html (summary of Canadian and Ontario environmental law by Weir & Foulds, lawyers)

http://www.blakes.ca/public/guide-ca.htm#environmental (environmental law chapter of *Lex Mundi*, about doing business in Canada by Blake Cassels & Graydon, lawyers)

APPENDIX G — GLOSSARY

Aerodrome	land or water facility at which aircraft can land and take off.
Airport	aerodrome that meets Transport Canada’s certification procedures for safety and emergency response.
AKC	Anti Knock Compound – the mixture added to gasoline to raise octane. Aviation mix AKC contains 61.49% TEL by weight.
Auto-ignition	spontaneous ignition of the air-fuel mixture inside the combustion chamber prior to presence of the spark intended to ignite the fuel. Commonly occurs after a spark ignition engine is shut down. See also “detonation”, “knock”, “ping”, “pre-ignition”.
Avgas	aviation gasoline, a special formulation for use in aircraft. There are two grades available in Canada, 80/87 and 100LL. The principal difference is the octane, which is achieved through the addition of tetraethyl lead. The TEL content of 80/87 is 140 mg/L, and for 100LL it’s 560 mg/L. Avgas differs from motor gasoline (mogas) in its energy content, vapour pressure, and lack of detergents and additives.

Commercial carriers — companies that carry passengers or freight for hire.

	Level I	at least a million passengers, or 200,000 tonnes of freight
	Level II	50,000 - a million passengers, or 10,000 - 200,000 tonnes of freight
	Level III	5,000 – 50,000 passengers, or 1,000 – 10,000 tonnes of freight
	Level IV	annual gross revenues of $250,000 or more for the services for which it is licensed
	Level V	annual gross revenues of less than $250,000 for the services for which it is licensed
	Level VI	licensed for the sole purpose of serving the needs of a lodge operation

Compression ratio	The ratio of the maximum to the minimum volume in the cylinder of an internal combustion engine. The ability of engine designers to increase the compression ratio depends on the fuel’s resistance to auto-ignition; this resistance is measured using an index called “octane”.
Detonation	rapid and uncontrolled combustion. Detonation can occur in the cylinder of a spark-ignited engine when operating on a fuel of inadequate octane, or with ignition timing too advanced. Often called “ping”.
General aviation	civil aviation activities, including recreational flying, private flying, specialty flying, flying by government-owned aircraft, and commercial services in Levels IV through VI
Jet fuel	a distillate similar in nature to diesel fuel used to power jet and turboprop engines. There are two types, kerosene-based and naphtha-based fuels.

Knock	noise from spontaneous ignition of a portion of the air-fuel mixture in a cylinder, occurring ahead of the normal spark-initiated flame front. If the mixture ignites spontaneously, there may be two or more flame fronts propagating within the cylinder; the collision of these flame fronts is the “knock”. It can cause severe engine damage, and will result in power loss and higher emissions. See also “auto-ignition”, “ping”, and “pre-ignition”.
ML	million litres
Mogas	motor gasoline. This gasoline is used for cars and trucks, and is unleaded. By regulation, the maximum lead content in mogas is 13 mg/L.
Ping	auto-ignition of the air-fuel mixture inside the combustion chamber prior to the timed spark. Sounds like rattling a handful of marbles together. See also “auto-ignition”, “knock”, and “pre-ignition”.
Pre-ignition	ignition of the air-fuel mixture before the timed spark. See also “auto-ignition”, “knock”, and “ping”.
Scavengers	Additives that act to prevent the build up of lead deposits in an engine’s combustion chamber by making the lead compounds sufficiently volatile that they will pass through the exhaust system.
TEL	Tetraethyl lead.
Turbo fuel	see jet fuel.
Valve recession	Intake and exhaust valves in an internal combustion engine open and close many times a second. When the valves seat on soft metal, there is the potential for them to pound the seats down; this is called valve recession. In older engines, a deposit of lead on the valve seats prevented valve recession. In newer engines, hardened valve seats or inserts prevents the problem.